NOTE

This manual documents the Model 8502A Digital Multimeter and its assemblies at the revision levels shown in Appendix 7A. If your instrument contains assemblies with different revision letters, it will be necessary for you to either update or backdate this manual. Refer to the supplemental change/errata sheet for newer assemblies, or to the backdating sheet in Appendix 7A for older assemblies.

8502A

Digital Multimeter

Instruction Manual

P/N 471466
March 1978
Rev 1 7/81

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All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

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*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

Rev. 6/81

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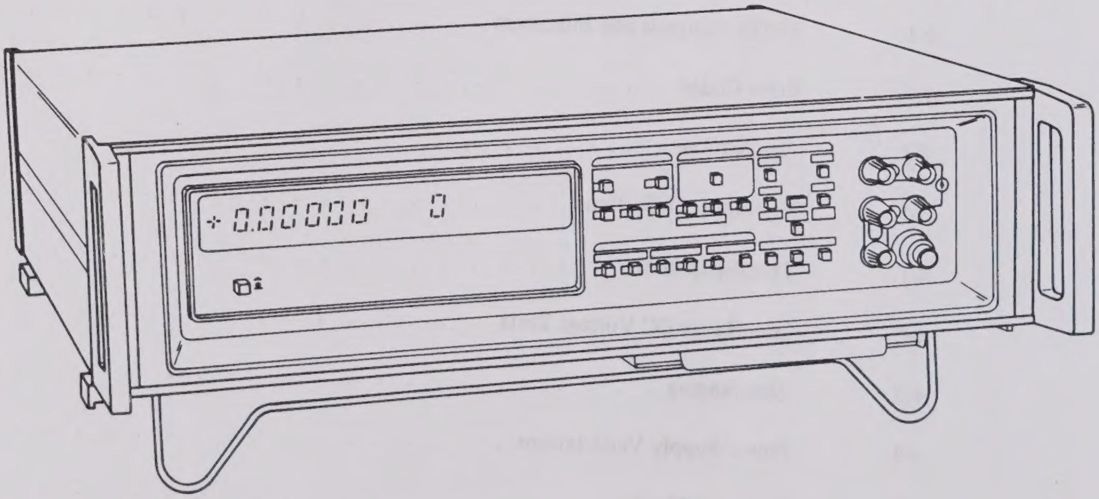


Model 8502A Digital Multimeter

Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. This manual comprises eight modular sections. You will find herein up-to-date information for installing, operating and maintaining the Fluke Model 8502A Digital Multimeter. Generally, complete descriptions and instructions are provided for the 8502A mainframe, modules necessary for DC Volts and DC Ratio measurement, and for any optional modules (AC Converter, Ohms Converter, etc.) that you may have ordered with your 8502A. Specifically, each section contains:

1. Section 1 – General description, specifications.
2. Section 2 – Operating instruction, capabilities.
3. Section 3 – Theory of operation, including simplified schematic and functional block diagrams.
4. Section 4 – Maintenance, adjustments and troubleshooting.
5. Section 5 – List of replaceable parts, with parts locators.
6. Section 6 – Option and accessory information, including complete information on any option ordered with the 8502A. As the need arises to broaden your 8502A's capabilities, the most recent information will be included with any options you order.
7. Section 7 – General information (list of abbreviations, federal supply codes, Service Centers, and Sales Respresentatives).
8. Section 8 – Schematic diagrams.

1-3. DESCRIPTION

1-4. The Model 8502A Digital Multimeter is a 6 1/2 digit instrument employing microprocessor control and a bus structure. Memory programming either from the front panel or through a remote interface permits a number of operations to be performed on the measured input before it is displayed. The standard configuration allows for measurement of dc volts in 5 ranges. Four ranges are available for ac volts when either optional ac converter is installed. Resistance can be measured in 8 ranges. Current can be measured in 5 ranges.

1-5. Modular Construction

1-6. Considerable versatility is realized through the 8502A's unique construction. All active components are contained in modules which plug into a mainframe motherboard. This module-motherboard mating, combined with bus architecture and microprocessor control, yields both ease of option selection and reduced downtime.

1-7. Microprocessor Control

1-8. All modules function under direct control of a microprocessor based controller. Each module is addressed by the controller as a memory location. External reference values and offsets can be applied separately, stored in memory, and automatically used as factors in all subsequent readings. Digital filtering utilizes averaged samples for each reading.

1-9. Recirculating Remainder A/D Conversion

1-10. The 8502A adapts Fluke's patented recirculating remainder (R^2) A/D conversion technique to microprocessor control. This combination provides fast, accurate, linear measurements and long-term stability.

1-11. Options and Accessories

1-12. Remote interfaces, AC converters, a current converter and an ohms converter are among the numerous options and accessories available for the 8502A. Refer to Tables 1-1 and 1-2 for complete listings. AC conversion can be accomplished with either an ac averaging module (–01) or a true RMS module (–09A). Any one of three remote interface modules (–05, –06, –07) may be installed at one time; the isolator module (–08A) must then be installed to maintain guarding of analog and high quality busses during remote operations. Maximum interfacing with digital systems is thus realized. Calibration downtime is reduced through the use of a calibration memory module (–04); correction factors may be entered from the front panel, providing automatic correction for further measurements. Analog inputs from a remote position are permitted when Rear Input (Option–17) is installed. Selectable front or rear analog inputs are available with Option –16.

1-13. SPECIFICATIONS

1-14. Mainframe specifications with DC Volts and DC Ratio measurement capability are presented in Table 1-3. Optional function specifications are supplied with the respective option modules and included in Section 6. The table of specifications presented here is divided into three parts:

1. General Specifications.
2. Accuracy.
3. Instrument Operating Characteristics.

Table 1-1. 8502A Options

Option No.	Name	Notes
01	AC/DC Converter (Averaging)	1, 3
02	Ohms Converter	
03	Current Shunts	3
04	Calibration Memory	
05	IEEE Standard 488–1975 Interface	2
06	Bit Serial Asynchronous Interface	2
07	Parallel Interface	2
08A	Isolator	4
09A	AC/DC Converter (True RMS)	1, 3
16	Front–Rear Switchable Input	5
17	Rear Input	

1) Options 01 and 09A cannot be installed simultaneously.
2) Only one of Options 05, 06, and 07 can be installed at any time.
3) For the AC portion of Option 03 to operate, either Option 01 or 09A must be installed.
4) Option 08A must be installed for remote operations.
5) Option 16 must be factory installed.

Table 1-2. 8502A Accessories

Model or Part No.	Name
M04-205-600	Rack Ear Mounting Assembly
M00-260-610	18-inch Rack Slides
M00-280-610	24-inch Rack Slides
80F-5	High Voltage Probe
80F-15	High Voltage Probe
81RF	High Frequency Probe
82RF	High Frequency Probe
KDM1	Keyboard Display Module w/Cable
Y8001	IEEE Std. Cable, 1 Meter Length
Y8002	IEEE Std. Cable, 2 Meter Length
Y8003	IEEE Std. Cable, 4 Meter Length
MIS-7011K*	Extender Assembly
MIS-7190K*	Static Controller
MIS-7191K*	Test Module
MIS-7013K*	Bus Interconnect and Monitor

*For use during service or repair

Table 1-3. Specifications

GENERAL SPECIFICATIONS

DIMENSIONS

	H		L		W
cm	10.8	x	42.5	x	43.2
Inches	4.25	x	16.75	x	17

WEIGHT

	Basic	Fully Loaded
kg	9.1	10.92
Lbs	20	24

OPERATING POWER

Basic Instrument	12 watts	115V ac or 230V ac ±10%
Fully Loaded	24 watts	50–60 Hz

WARM-UP

2 hours to rated accuracy

SHOCK AND VIBRATION

Meets requirements of MIL-T-28800 for Class 5 style E equipment.

TEMPERATURE RANGE

Operating	0°C to 50°C
Non Operating	–40°C to 70°C*

**0°C to 50°C operating and non-operating with calibration memory option (–04) installed.*

HUMIDITY RANGE

(Operating to Full Accuracy)

0°C to 18°C	80% RH
18°C to 40°C	75% RH
40°C to 50°C	60% RH

OVERLOAD

LO to Guard	127V max
Guard to Chassis	1000V max
HI Sense to HI Source	127V max
LO Sense to LO Source	127V max
HI Sense to LO Sense	1000V max
HI Source to LO Source	280V max

ACCURACY

Note

The stated accuracies are valid under the following environmental conditions.

Temperature: 18°C to 28°C (Except 24 hour: 22°C to 24°C)

Humidity: ⩽75%

Line Regulation: 90V to 110V, 103.5V to 126.5V, or 207V to 253V @ 45 to 66 Hz

DC Volts

Normal Resolution (5 1/2 digits)

Range	Full Scale	Resolution	Accuracy ± (% of Input + Number of Digits)		
			24 Hours	90 Days	1 Year
100 mV	312 mV	1 uV	0.002 + 4	0.003 + 5	0.005 + 8
1 V	2.5 V	10 uV	0.001 + 1	0.002 + 1	0.004 + 1
10 V	20 V	100 uV	0.001 or 1*	0.001 + 1	0.002 + 1
100 V	160 V	1 mV	0.001 + 1	0.002 + 1	0.004 + 1
1000 V	1200 V	10 mV	0.001 + 1	0.002 + 1	0.004 + 1

**Whichever is greater.*

Table 1-3. Specifications (cont)

ACCURACY (Continued)

DC Volts (Continued)

High Resolution (HI RES or CAL – 6 1/2 digits)

Range	Full Scale	Resolution	Accuracy ± (% of Input + Number of Digits)		
			24 Hours	90 Days	1 Year
1 V	2.5 V	1 uV	0.001 + 6	0.002 + 8	0.004 + 9
10 V	20 V	10 uV	0.0006 or 6*	0.001 + 8	0.002 + 9
100 V	160 V	100 uV	0.001 + 6	0.002 + 8	0.004 + 9
1000 V	1200 V	1 mV	0.001 + 6	0.002 + 8	0.004 + 9

**Whichever is greater.*

DC Ratio

Ext. Ref. Voltage	Accuracy
$\pm$20V to $\pm$40V	$\pm$(A + B + 10 ppm)
$\pm V_{min.}$* to $\pm$20V	$\pm\left(A + B + \frac{200\ ppm}{\lvert V_{xref}\rvert}\right)$

A =10V dc Range Accuracy

B =Input Signal Function and Range Accuracy

V_{min} =Minimum Allowable External Reference Voltage

$|V_{xref}|$ =Absolute Value of External Reference Voltage

The formula for determining V_{min} is included in Instrument Operating Characteristics

Example Calculations for External Reference Accuracy: (90 days, 5½ digits)

1. Input = + 90.000V, Ext. Ref. Input = 30.000V (+ 15V to Ext. Ref. HI, –15V to Ext. Ref. LO)
   A = .001% + 1 Digit B = .001% + 1 Digit
   Ratio Accuracy = $\pm$(A + B + 10 ppm) = $\pm$(.001% + 1 Digit + .001% +1 Digit + .001% = $\pm$(.003% +2 Digits)
   Reading may be between 3.0003 and 2.9997

2. Input = 1.20000V, Ext. Ref. Input = .12000 (V_{min} for 1V Range)
   A = .001% + 1 Digit, B = .001% + 1 Digit, $\frac{200\ ppm}{V_{xref}} = \frac{.02\%}{.12} = .1667\%$

   Ratio Accuracy = $\pm$.001% + 1 Digit + .001% +1 Digit + .1667%) = $\pm$(.1687% + 2 Digits)
   Reading may be between .998313 and 1.001686.

INSTRUMENT OPERATING CHARACTERISTICS

DC Volts

TEMPERATURE COEFFICIENT
(0°C to 18°C and 28°C to 50°C)

Range	Temperature Coefficient
100 mV	± (3 ppm/reading + 0.5 digit)/°C
1V	$\pm$(3 ppm/reading +0.1 digit)/ °C
10 V	± (2 ppm/reading + 0.05 digit)/°C*
100 V	± (3 ppm/reading + 0.1 digit)/°C*
1000 V	± (3 ppm/reading + 0.05 digit)/°C*

**For High Resolution Multiply Digits by 10.*

INPUT IMPEDANCE

Range	Input Impedance
100 mV	>10,000 MΩ
1V	>10,000 MΩ
10 V	>10,000 MΩ
100 V	10 MΩ
1000 V	10 MΩ
Guard to Chassis	∞

INPUT BIAS CURRENT

	At time of Cal	30 Days (23°C ± 1°C)	Temperature Coefficient
Bias Current	<± 5 pA	<± 50 pA	± 3 pA/°C

Table 1-3. Specifications (Cont)

INSTRUMENT OPERATING CHARACTERISTICS (Continued)

DC Volts (Continued)

RESPONSE TIME

Digitizing Time			Analog Settling Time Within Voltmeter		
Reading Rate*		Digitizing Time	Filter Mode	Step Input to 0.01% of Change	Step Input to 0.001% of Change
50 Hz line	4 Samples/Rdg	22 ms	Filter, Fast	40 ms	50 ms
	32 Samples/Rdg	162 ms	Bypass	2 ms	20 ms
	128 Samples/Rdg	642 ms	Bypass	2 ms	20 ms
60 Hz line	4 Samples/Rdg	18 ms	Filter, Slow	400 ms	500 ms
	32 Samples/Rdg	136 ms	Bypass	2 ms	20 ms
	128 Samples/Rdg	546 ms	Bypass	2 ms	20 ms

**Number of samples per reading is programmable from 1 (2^0) to 131,072 (2^{17}) in 18 binary steps.*

ZERO STABILITY	OVERLOAD
Better than 5 μV for 90 days after a one hr. warm-up. Front Panel pushbutton auto zero is provided. The zero correction is stored in memory until power is interrupted or the 8502A is RESET. If calibration memory Option –04 is installed, the zero correction is retained.	±1200V DC, 1200V peak to 60 Hz, or 1400V peak above 60 Hz may be applied continuously to any dc range without permanent damage. Maximum common mode rate of voltage rise is 1000V/μsec.

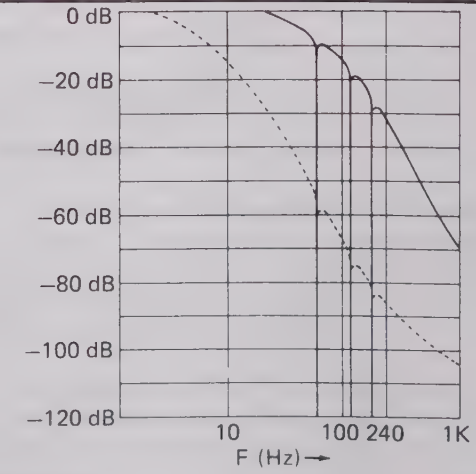
NOISE REJECTION

Normal Mode				Common Mode	
Line/Filter Frequency	4 Samples/Rdg	32 Samples/Rdg	128 Samples/Rdg	True	Effective
50 Hz Fast Filter	60 dB	70 dB	75 dB	100 dB at 60 Hz for 1 KΩ unbalance	Sum of Common Mode Rejection and Normal Mode Rejection
50 Hz Slow Filter	85 dB	90 dB	95 dB		
60 Hz Fast Filter	60 dB	70 dB	75 dB		
60 Hz Slow Filter	90 dB	95 dB	100 dB		

128 SAMPLES/READING

Typical Performance with 60 Hz Line (Combined digital and analog filtering)

Cusps shown are at multiples of 60 Hz line frequency. Similar cusps (not shown) occur every 7½ Hz.



- - - - - Slow Filter

——— Fast Filter

Table 1-3. Specifications (Cont)

INSTRUMENT OPERATING CHARACTERISTICS (Continued)

DC Ratio

INPUT IMPEDANCE	SOURCE IMPEDANCE
Ext Ref HI or LO > 10,000 MΩ relative to Ohms Guard* or Sense LO	Resistive Unbalance (Ext Ref HI to LO) <4 kΩ Total Resistance Sense LO from either HI or LO <20 kΩ
BIAS CURRENT	**OVERLOAD (Ext Ref HI or LO)**
Ext Ref HI or LO relative to Ohms Guard* or Sense LO <5 nA	±180 volts peak , 127V rms (relative to Ohms Guard* or Sense LO) X (360V peak HI to LO)

** Ohms Guard available through rear input (–16 or –17 Option)*

NOISE REJECTION

Normal Mode	Common Mode, All Inputs Driven
Sense Input—Same as dc volts	**Sense Input**—Same as dc volts
Ext Ref Input—dc, line frequency and 2x line frequency >100 dB	**Ext Ref Input**—Line frequency and 2x line frequency, 75 dB

RESPONSE TIME

Settling Time

Sense Input Fast Filter < 50 ms to 0.001% of change
Sense Input Slow Filter < 500 ms to 0.001% of change

Digitizing Time

NOTE

The Sense Input is measured prior to measuring Ext Ref HI and LO.

Ext Ref Input—Each input HI and LO

90 ms at 60 Hz line frequency
107 ms at 50 Hz line frequency

Ext Ref Calibration—12 ms

Sense Input		
Line Volt	Approx. Rdg. Rate	Digitizing Time
60 Hz	4½ rdg/s 1½ rdg/s	136 ms 536 ms
50 Hz	3½ rdg/s 1¼ rdg/s	162 ms 642 ms
60 Hz	4 samples/rdg	18 ms
50 Hz	4 samples/rdg	22 ms

EXT REF VOLTAGE RANGE

Maximum Ext Ref Voltage = ± 40V between Ext Ref HI and LO terminals, providing neither terminal is greater than ± 20V relative to the Sense LO or Ohms Guard terminals.

Minimum Ext Ref Voltage = ±0.0001V, or $\frac{V_{\text{input}}}{10^9}$ (whichever is greater)

MAXIMUM DISPLAY— Ratio, Scaling or Offset Mode = ±1.00000 x 10^9 in all Ranges

Section 2

Operating Instructions

2-1. INTRODUCTION

2-2. Installation and operation of the 8502A Digital Multimeter are explained in this section. The 8502A's full capabilities may be realized by thoroughly reading and understanding these operating instructions. Explanations and applications are provided for all standard functions and operations. Read them. Should any difficulties arise, contact your nearest Fluke Sales Representative (list in Section 7), or the John Fluke Mfg. Co., Inc. (P.O. Box C9090, Everett, Wa., 98206; tel. (206) 342-6300).

2-3. SHIPPING INFORMATION

2-4. The 8502A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included with the shipping container.

2-5. If reshipment is necessary, the original container should be used. If the original container is not available, a new container can be obtained from John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INSTALLATION

2-7. Non-marring feet and a tilt-down bail are installed on the instrument for field or bench use. A rack-mounting kit and rack slides are available for use with standard 19-inch equipment racks. Information regarding installation or rack-mounting accessories is contained in Section 6.

2-8. The 8502A operates from either 115V ac ±10% or 230V ac ± 10%, 50 or 60 Hz (10% tolerance translates to high and low limits of: 103.5 to 126.5V ac, 207 to 253V ac).

WARNING

TO AVOID ELECTRICAL SHOCK, PROPERLY GROUND THE CHASSIS. A GROUND CONNECTION IS PROVIDED IN THE THREE-PRONG POWER CONNECTOR; IF PROPER GROUND IN YOUR POWER SYSTEM IS IN DOUBT, MAKE A SEPARATE GROUND CONNECTION TO THE REAR PANEL CHASSIS BINDING POST. OTHERWISE, THE POSSIBILITY OF ELECTRICAL SHOCK MAY EXIST IF HIGH VOLTAGE IS MEASURED WITH THE LEADS REVERSED (INPUT HI GROUNDED).

2-9. OPERATING FEATURES

2-10. Display, control, and terminal locations on the 8502A can be found in Figure 2-1. Table 2-1, will then detail respective functions. In addition, a convenient set of condensed operating instructions is provided under the instrument's front right side. Just pull out the tab.

2-11. OPERATING NOTES

2-12. Input Power

2-13. A binding post on the rear panel has been provided as an earth ground connection. Power supply switching (115V or 230V ac) is explained in Section 4. With the exception of slower reading rates and filter time outs, operation at 50 Hz is identical to that at 60 Hz.

2-14. The line fuse (.5A MDL Slow Blow) is located on the rear panel, near the heatsink. The current protection fuse (1.5A AGC) is located in the lower right-hand corner of the front panel.

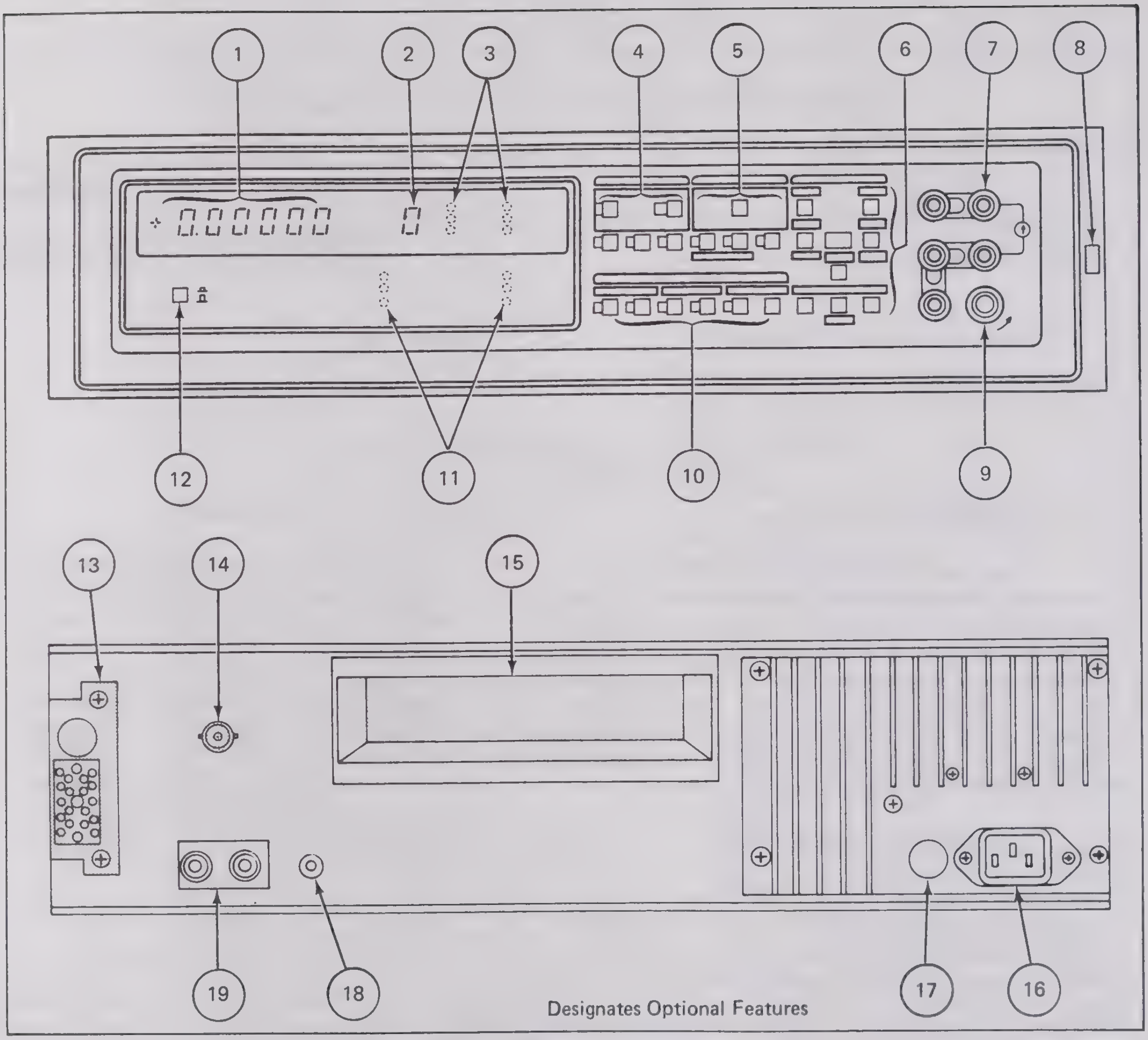


Figure 2-1. 8502A Controls and Indicators

Table 2-1. 8502A Controls and Indicators

REF. NO.	NAME	FUNCTION
1	Digit Display	Displays 5 1/2 digits with polarity and properly positioned decimal point. When instrument is in Hi Res mode, the exponent display will be used as an extra digit (for 6 1/2 digits).
2	Exponent Display	Displays polarity and value of exponent for engineering notation.
3	Range and Function Indicators	LED's illuminate to identify function and autoranging selection.
4	FUNCTION Controls	Push to select volts (VDC, VAC), current (A DC, A AC), or OHMS. Serve as dual function controls for numeric entries.

Table 2-1. 8502A Controls and Indicators (cont)

REF. NO.	NAME	FUNCTION
5	RANGE Controls	Manually shift range up or down. Enter high resolution mode. Select auto or manual ranging. Recall (HI, LO) peak or limit. Store (HI, LO) limit values. Serve as dual function controls for numeric entries.
6	MEMORY Controls	Toggle into/out of LIMITS, PEAK, CAL, OFFSET or SCALING. RECALL Memory values. Manual TRIGGER. STORE applied values, numerics. ENTER or clear (CE) numerics.
7	INPUT Terminals	SENSE INPUT HI and LO for volts, ohms. INPUT SOURCE HI and LO for amps, ohms. Guard Current protection fuse. GUARD.
8	(REAR INPUT IN)	Optional (–16)
9	Current Fuse	Use AGC 1.5A
10	MODIFIER Controls	RESET RESUME REMOTE EXT REF FILTER SAMPLE Numerics
11	Status Display	LED's light for: Slow filter Sample (flashes at reading rate) SCALING selected REMOTE selected OFFSET selected PEAK selected LED's flash if CAL or EXT REF selected
12	Power Switch	Push on/Push off
13	(Rear Input Connector and Fuse)	Optional connections for remote input and external reference terminals (–16, –17).
14	(External Trigger Input)	Optional (–08A)
15	(Interface Connectors and Switches)	Optional remote interface module accessible in this area (–05, –06, –07)
16	Power Connector	Three-prong connector accepting line cord with ground wire.
17	Line Fuse	Use MDL .5A (slow blow).
18	Chassis Ground	Binding post for ground interconnections.
19	External Reference Terminals	Apply external reference voltage. (40V max between HI and LO).

2-15. Display

2-16. DESCRIPTION

2-17. The 8502A's display consists of a digit readout, exponent, and LED annunciators for indication of instrument function and status. Specifically, these features provide:

1. 5 1/2 or 6 1/2 digit display with polarity, automatic reading and decimal placement.
2. Exponent display with polarity for readings in engineering notation. Serves as an extra digit of resolution in Hi Res and Cal modes.
3. Function and autoranging indicators light for function selected and for autoranging.
4. Status indicators give a constant illumination to signify selection of REMOTE, OFFSET, PEAK, SCALING, slow FILTER. Dual function LED's will flash to indicate selection of CAL or EXT REF. SAMPLE LED will flash at the reading rate selected (with more than 128 samples per reading, the LED will flash at the same rate to denote a reading in progress).
5. Power ON LED.

2-18. WARNING INFORMATION

2-19. The digit and exponent displays will provide warning indications and error codes.

1. "HHHHHH" will flash at the reading rate if the input voltage exceeds the full scale value for the range selected. Full scale values are included with the specifications in Section 1.
2. "H" will flash in the exponent display should an input voltage greater than 40V occur when in the Scaling, External Reference or Offset modes.
3. These flashing indications will not be seen when in the Cal mode.

NOTE

Flashing indicators in the digit or exponent display are a warning only; they have no effect on instrument operation.

4. Error codes will be provided in the digit and exponent displays when appropriate. Consult Table 2-2 for applicable meanings.

NOTE

Error codes will not be displayed in Cal mode. Random readings will then be the only indication of an invalid function or faulty module.

Table 2-2. Error Codes

CODES	FAULT
Error	System error — if this error message appears prior to the introductory messages at power initialization or reset, the problem is with the calibration memory module.
Error 0	VDC/Ohm Zero Error — either a VDC/Ohm Zero was attempted in a range other than 100 mV or 10 ohms, or an overrange was entered.
Error 1	Store during overload condition attempted.
Error 2	Filter module error — the module is faulty or not installed.
Error 3	DC Signal Conditioner error — the module is faulty or not installed.
Error 4	Ohms or Current error — excessive voltage applied to the selected module, shorting links not properly connected, or the selected module is faulty.
Error 5	R^2 A/D error — the recirculating remainder analog to digital converter module is faulty or not installed.
Error 6	Numeric display overflow error.
Error 7	External Reference error — the magnitude of one of the external reference inputs is greater than 20V dc.
Error 8	Controller error — the module is faulty or not installed.
Error 9	Function Selection error — the function module selected, other than dc volts, is faulty or not installed.
Error C	Invalid switch sequence during Recall or Store operations.

2-20. SPECIAL CONSIDERATIONS

2-21. Cal

2-22. Use of the Cal mode will significantly change normal display indications. As noted above, no warning indications will be displayed. Further, the exponent display will now serve as an extra digit of resolution (yielding 6 1/2 digit resolution).

2-23. Hi Res

2-24. The exponent display will be used as an extra digit of resolution in the High Resolution mode (not used in the 100 mV or 100 uA ranges). No exponent will be displayed.

Although not visible in Hi Res, the exponent remains in effect; care should be exercised when interpreting readings. To avoid confusion, remember that an exponent in the exponent display will always have its own polarity sign; a high resolution digit will not.

2-25. Input Terminals

2-26. TERMINAL INTERCONNECTIONS

2-27. For dc voltage measurements, both INPUT HI terminals may be left strapped together, The INPUT LO terminals may likewise remain strapped. For most measurements, it is sufficient to strap GUARD to INPUT LO. Refer to Figure 2-2, for recommended input terminal strapping.

CAUTION

The guard terminal should not be left disconnected. Instrument damage can occur if common mode voltage exceeds the LO to GUARD maximum voltage rating (127V).

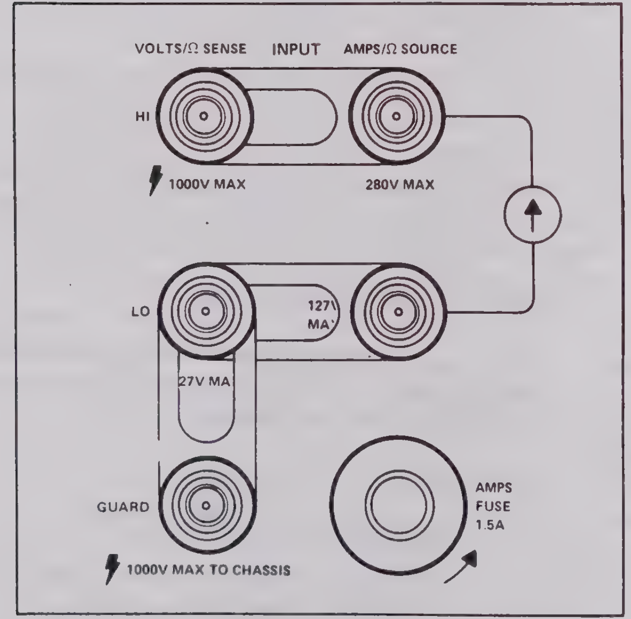

VOLTS/Ω SENSE
INPUT
AMPS/Ω SOURCE
HI
1000V MAX
280V MAX
LO
127V MAX
127V MAX
GUARD
1000V MAX TO CHASSIS
AMPS
FUSE
1.5A

Figure 2-2. Front Panel Terminal Interconnections

2-28. GUARDING

2-29. Common mode voltages, resulting from currents and voltage drops between two points otherwise electrically common, may produce significant errors. Proper use of a floating, guarded voltmeter will minimize these errors and allow representative reading of normal mode voltages (actual source voltage and noise).

2-30. Correct use of the 8502A's guard terminal will both protect the instrument and provide more accurate readings. Since the LO to GUARD maximum voltage rating is 127V, the guard terminal should always be connected either to the INPUT LO terminal or to a point in the source circuit to be measured. For accurate readings, connect the guard to minimize common mode currents flowing through any resistance which helps determine the voltage being measured. See Figure 2-3, for suggested guard connections.

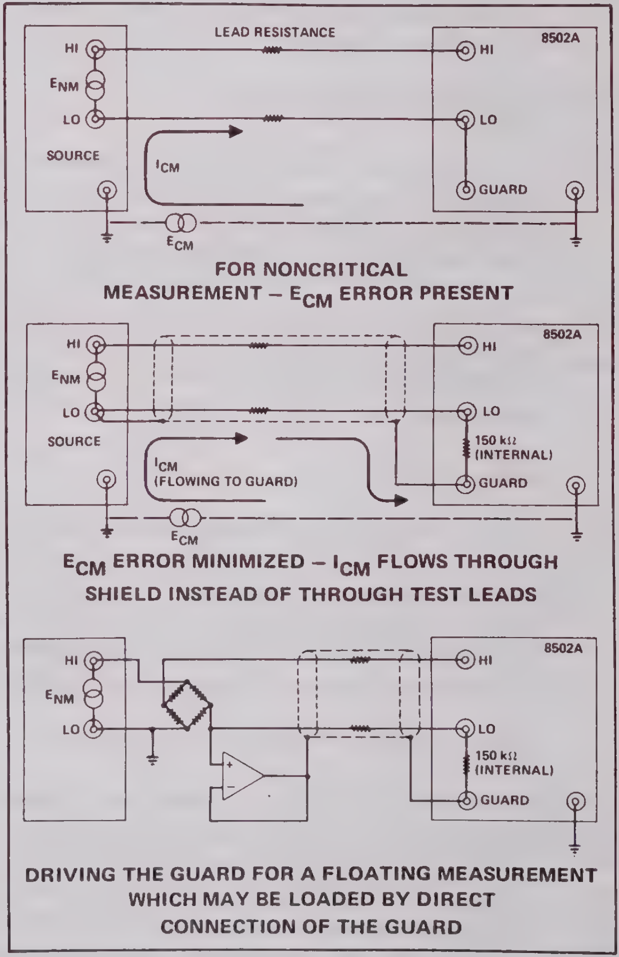

LEAD RESISTANCE
HI
E_{NM}
LO
SOURCE
I_{CM}
8502A
HI
LO
GUARD
E_{CM}
FOR NONCRITICAL MEASUREMENT – E_{CM} ERROR PRESENT
HI
E_{NM}
LO
SOURCE
I_{CM} (FLOWING TO GUARD)
8502A
HI
LO
150 kΩ (INTERNAL)
GUARD
E_{CM}
E_{CM} ERROR MINIMIZED – I_{CM} FLOWS THROUGH SHIELD INSTEAD OF THROUGH TEST LEADS
HI
E_{NM}
LO
8502A
HI
LO
150 kΩ (INTERNAL)
GUARD
DRIVING THE GUARD FOR A FLOATING MEASUREMENT WHICH MAY BE LOADED BY DIRECT CONNECTION OF THE GUARD

Figure 2-3. Guard Connections

2-31. Generally, guarding should be used in the following situations:

1. When long signal leads are used.
2. When signal source impedance is high.
3. When making measurements near high-level radiated noise, particularly at the power line frequency.
4. When making floating measurements.

NOTE

> *Errors due to thermal EMF's should be considered when making low level, high resolution measurements. Thermal EMF's (voltages produced by temperature differences between contacts of two dissimilar metals or by temperature gradients along a length of material) may cause differences in potential of several microvolts. Since the 8502A utilizes gold-plated input terminals, the use of low EMF, shielded cables with gold-plated spade lugs will minimize thermal EMF errors.*

2-32. Front Panel Controls

2-33. Most front panel controls are momentary contact switches. If held in continuously, such switches will be read only one time. In addition, some of these switches will hold a particular reading in the 8502A's display for as long as they are held depressed. Front panel switches may have 1, 2, or 3 functions; switch sequencing will determine which function is in effect for multi-function switches. Refer to "OPERATING DIRECTIONS" later in this section for detailed front panel control procedures.

2-34. Function

2-35. The DC volts function is standard with this instrument; optional modules must be included for all other functions. Complete information for any options included with your 8502A can be found in Section 6 of this manual. If a function is selected for which the appropriate module is not installed, "Error 9" will appear in the display.

2-36. Range

2-37. DC volts can be measured on five successive ranges from 100 mV to 1000V. Respective resolutions vary from 1 uV to 1 mV. Input impedance on the 100V and 1000V ranges is 10 Mohms. On the lower three ranges it is greater than 10,000 Mohms. Overrange capabilities, DC voltage accuracies, and overload protection conditions are detailed in Section 1 of this manual.

2-38. Modifiers

2-39. FILTER

2-40. The 8502A has five filter modes.

1. F – slow filter, no time out – FILTER LED on.
2. F0 – fast filter, no time out.
3. F1 – filter bypass.
4. F2 – slow filter, with time out (550 msec, settling time) – FILTER LED on.
5. F3 – fast filter, with time out (50 msec, settling time).

("Fast" and "slow" refer to the respective filter's settling time.)

2-41. The slow filter will provide better line frequency rejection; the fast filter discriminates against higher frequency and harmonically related line noise. Time outs are always inserted before the first reading is taken in a newly selected function or range. With F2 or F3 selected, time outs will always be inserted before each subsequent reading in that function or range.

2-42. SAMPLE

2-43. Samples taken in the 8502A can be synchronous or asynchronous to the line frequency. Line frequency noise rejection can be increased by averaging more samples per displayed reading (refer to NOISE REJECTION specifications in Table 1-3 of this manual.) Provision is therefore made to change the number of samples taken for each reading (display update). Setting the samples per reading will yield a specific reading time. Additional time per reading will be necessary whenever memory operations (Offset, Scaling, etc.) are involved. Ohms measurements will also require more time due to the multiple readings involved.

2-44. For example, if rate 7 is selected, 128 samples will be taken and averaged per reading. With no memory operations involved, digitizing time for a dc volts reading will therefore take 533 ms. Sample rate designations (such as 7) are actually the number of samples per reading expressed as exponents of 2; rate 7 = 2^7 = 128 samples per reading.

2-45. EXTERNAL REFERENCE

2-46. An external reference dc voltage can be used to divide the inputs in any function. A true ratio measurement is then computed by the Controller.

$$\text{Reading} = \frac{\text{Input}}{\text{dc Ext. Ref. Input}}$$

2-47. A pair of external reference terminals will be found either separately on the rear panel or together in the optional rear input connector.

1. The applied external reference voltage may be a maximum of ±20V at either external reference HI or LO or 40V between HI and LO, with respect to SENSE LO (or to Ohms Guard in the rear input connector).

2. The minimum voltage applicable to the external reference terminals is the greater of either ±100 uV, or a value found with the following formula:

$$V_{min} = \frac{\pm\ |V_{in}|}{10^9}$$

3. The resistance between either EXT REF terminal and INPUT LO should be less than 20 Kohms. Normally, EXT REF LO will be tied to INPUT LO.

2-48. REMOTE

2-49. If an optional remote interface is installed, the REMOTE switch may be used to toggle into or out of remote control. With the IEEE (Option –05) Interface installed, only toggling out of remote control is permitted from the front panel. When in remote control, only the remote switch and the power switch will have any effect on the instrument's operation. A reset caused by power interruption will return the instrument to local control.

2-50. Remote control does not affect analog inputs on the High Quality Bus. With Rear Input (Option –17) or Switchable Front - Rear Inputs (Option –16), separate Sense Hi and Lo, Source Hi and Lo, Guard, Ohms Guard, and External Reference connections must be made remotely.

2-51. Memory

2-52. The 8502A provides considerable versatility in measurement manipulations through both front panel and remote programming. Displayed numbers are computed from measured data according to the following general equation, where:

y = the displayed number

m = the scaling factor or external reference

x = the actual input (averaged samples)

b = the offset factor (subtracted)

Thus:

$$\left[y = \frac{x}{m} - b \right]$$

2-53. Either displayed values or numeric sequences may be stored as memory factors.

NOTE

Storing a value in memory does not select a mathematical operation. The operation must be selected separately before or after the value is stored.

2-54. LIMITS

2-55. Any currently displayed value may be stored as a limit value. With such values stored as references, the 8502A (toggled into the Limits mode) will yield a display of:

1. HI if the reading is greater than the high limit.

2. PASS if the reading is less than or equal to the high limit and greater than or equal to the low limit.

3. LO if the reading is less than the low limit.

NOTE

HI, LO, and PASS describe the normally displayed reading, with all math operations completed, relative to the limit values.

2-56. Only one set of limits may be stored at a time. A function change will exit the Limits mode but retain stored values.

2-57. PEAK

2-58. Highest and lowest values displayed in any series of measurements may be stored when in the Peak mode. Toggle in and out of this mode by depressing the PEAK switch. Peak values will be retained after the mode is deactivated but lost should the instrument be reset or the mode reselected.

2-59. CALIBRATION MODE

2-60. The CAL switch will be found on the front panel behind a small plastic cover which pulls out and hinges down. Sliding the switch down places the 8502A in the Calibration mode. This mode is designed primarily to be used with the Calibration Memory (Option –04). When this module is installed and the instrument is in the Calibration mode, correction factors can be stored at the decade point for each range and function. Refer to Section 6 of this manual for complete Calibration Memory procedures.

2-61. If the Calibration Memory is installed, inadvertent use of the STORE switch will store the last reading as a calibration factor and erase calibration factors for the function and range in use at the time. To correct this possible mistake without a calibration standard, disconnect the input, short the input terminals, and press STORE again.

2-62. Whether or not the Calibration Memory module is installed, entry into the Calibration mode (CAL LED flashes) necessitates consideration of the following alterations to the 8502A's display:

1. The exponent is replaced with an extra digit of resolution.
2. Error codes are disabled. Only spurious readings will now denote selection of an invalid function.
3. The overrange indication is disabled.

NOTE

When changing from one function to another, or upon entering the Cal mode, memory modes will be deactivated. Stored values will be retained. Use of RESET or interruption of power to the 8502A will erase memory entries.

2-63. OFFSET

2-64. The Offset mode can be used to automatically subtract a number from the measured input and display the result. The subtracted offset number may be:

1. Any currently displayed value.
2. A programmed numeric entry (ranging from $+10^9$ to -10^9).

2-65. The displayed reading in Offset mode will exhibit no increase in digit resolution. Only one offset factor at a time can be stored. A function change will deactivate Offset mode; the stored value will be retained. A flashing H will appear in the exponent display should more than 40V appear between the input terminals when in Offset mode.

2-66. SCALING

2-67. The Scaling mode may be used to automatically divide a measured input by a programmed number or by an applied value. This feature essentially provides the ability to program an external reference without standard external reference limitations in range. In fact, scaling values may range from $+10^9$ to $+10^{-9}$ and from -10^9 to -10^{-9}. A scaling factor of 0 is not allowed. Scaled readings will contain 3 significant digits if the original reading had 3 or less significant digits. For more than 3 significant digits in the original reading, the scaled reading will display the same number of significant digits. Only one scaling factor may be stored at a time. A function change will deactivate the Scaling mode but retain the stored factor.

NOTE

If the 8502A is in both Scaling and Offset, the scaling factor will be applied first; the scaled displayed values will then be offset.

2-68. ZEROING

2-69. There are two methods of zeroing the 8502A. Either method may be used in the 100 mV range or the 10 ohm range.

2-70. VDC/Ohms Zero

2-71. Correction for internal dc drift can be made by applying a good quality, low thermal short between HI and LO terminals (not between test leads). If necessary, repeat this operation once the instrument has warmed up. Only dc volts zero factors may be recalled.

2-72. Zeroing with OFFSET

2-73. After zeroing for internal drift, separate dc volts and 2-wire ohms measurement corrections can be made by shorting the test leads and storing the reading as an offset factor.

2-74. Systems Use of the 8502A

2-75. The availability of optional interface modules makes the 8502A adaptable to a large variety of digital systems. Operating and programming instructions related to remote operation are included with the appropriate optional module. Overall information on remote interfacing can be found in Fluke Application Bulletin –25 "System Use of the Fluke Model 8500A", Specific information about the IEEE interface (–05 Option) may be found in Fluke Application Bulletin –36. Application Bulletin –37 "Unique Measurements Using the 8500 Series Digital Voltmeter" will also be useful for both local and systems use of the 8502A.

2-76. OPERATING DIRECTIONS

2-77. Initial Settings

2-78. Upon applying power to the 8502A, the display will read:

"HI – 2.0.Y"

("Y" will be the number of the software version employed in your instrument.) Then:

"CXXXXX"

("X" will be identifying numbers for installed options.)

The instrument will now assume the following status:

1. V DC function
2. 1000V range
3. Slow reading rate (7)
4. Fast filter (F0)

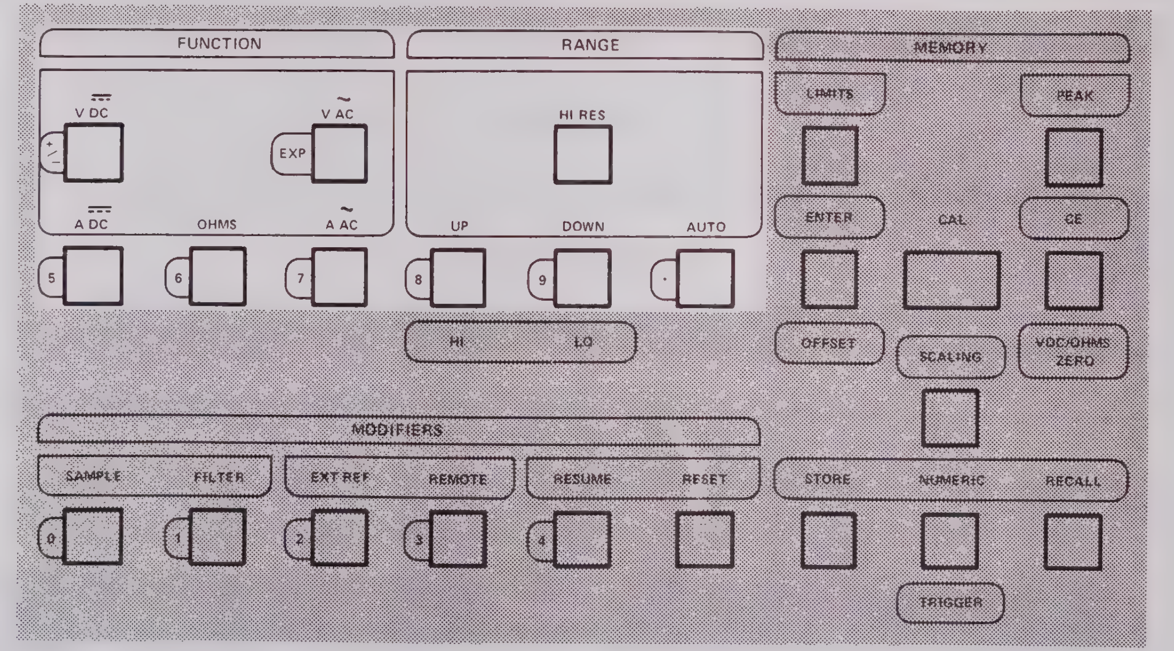
5. Offset – off and zeroed
Scaling – off and set to 1
Peaks – off and set to 0
Ext Ref – off
Trigger – Auto
VDC/Ohmx Aero – zeroed
Remote – out, in local.

2-79. Allow a 1 hour warm-up to insure rated accuracy.

2-80. Front Panel Control Usage

2-81. Figures 2-4, 2-5, 2-6, and 2-7 will describe 8502A front panel control usage. When initially setting these controls, use the following grouping sequence:

FUNCTION → RANGE → MODIFIERS → MEMORY


FUNCTION
RANGE
MEMORY
V DC
V AC
EXP
HI RES
LIMITS
PEAK
A DC
OHMS
A AC
UP
DOWN
AUTO
ENTER
CAL
CE
5
6
7
8
9
.
HI
LO
OFFSET
SCALING
VDC/OHMS ZERO
MODIFIERS
SAMPLE
FILTER
EXT REF
REMOTE
RESUME
RESET
STORE
NUMERIC
RECALL
0
1
2
3
4
TRIGGER

FUNCTION

Depress the switch for the desired function. The 8502A will assume autoranging (AUTO LED on) and retain any modifier (sample, filter, etc.) or memory (scaling, offset, etc.) mode already in use. If a function is selected for which the module is either faulty or not installed, Error 9 will appear in the display. Press RESET or select another function to clear this error indication. Otherwise, the appropriate function LED will come on when one of the following functions is selected:

1. DC VOLTS (V DC) – Standard, 5 ranges.
2. AC VOLTS (V AC) – Optional, 4 ranges.
3. DC CURRENT (A DC) – Optional, 5 ranges.
4. AC CURRENT (A AC) – Optional, 5 ranges.
5. Resistance (OHMS) – Optional , 8 ranges.

Figure 2-4. Function and Range

RANGE

Range switching in the 8502A can be either manual or automatic.

☐ UP ☐

Advances 8502A to the next higher range with each application. UP will have no effect at the top of the range. If the 8502A is in autoranging, application of UP will both shift to manual range and change the range.

☐ DOWN ☐

Steps 8502A to the next lower range each time it is depressed. DOWN will have no effect at the bottom of the range.

☐ AUTO ☐

Toggles the 8502A into/out of the Autoranging mode.

☐ HIGH RESOLUTION ☐

Depress the HI RES switch to enter this mode (not available in 100 mV DC or 100 mA range). Depress it a second time to exit the mode. Don't forget that, although the exponent is not displayed, it does remain in effect.

Figure 2-4. Function and Range (cont)

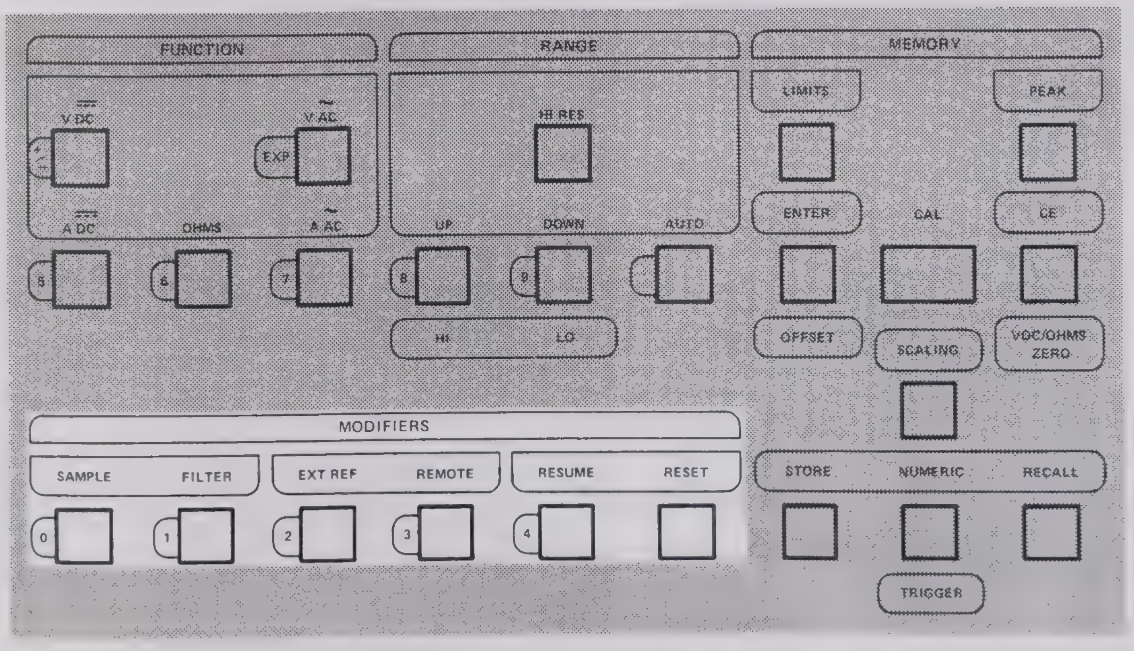

FUNCTION
RANGE
MEMORY
V DC
V AC
EXP
HI RES
LIMITS
PEAK
A DC
OHMS
A AC
UP
DOWN
AUTO
ENTER
CAL
CE
5
6
7
8
9
HI
LO
OFFSET
SCALING
VOC/OHMS ZERO
MODIFIERS
SAMPLE
FILTER
EXT REF
REMOTE
RESUME
RESET
STORE
NUMERIC
RECALL
0
1
2
3
4
TRIGGER

Figure 2-5. Modifiers

☐ SAMPLE ☐

1. Press SAMPLE to toggle between samples/reading rates 5 and 7.

2. Alternately, any rate between 0 and 17 may be programmed from the front panel. Press:

   STORE → NUMERIC → SAMPLE → (rate number) → ENTER

   The new rate will go into effect as soon as ENTER is pressed.

3. To display the samples/reading rate, press:

   RECALL → SAMPLE

   The rate will be displayed as long as SAMPLE is held depressed.

4. The SAMPLE LED will flash at the samples/reading rate selected. With more than 128 samples/reading (rate 7) there will be no distinguishable rate difference from the LED's indications at rate 7.

☐ FILTER ☐

1. Press FILTER to toggle between filter modes F and F0. The FILTER LED will come on for F (slow filter).

2. Use the following switches to select filter modes F, F0, F1, F2, or F3:

   STORE → NUMERIC → FILTER → (–, 0, 1, 2, or 3) → ENTER

3. Display the filter mode in effect by pressing:

   RECALL → FILTER

   The mode will be displayed as long as FILTER is held depressed.

4. If modes F1 or F3 are in effect, subsequent use of FILTER will toggle the 8502A back to mode F. If mode F2 is in effect, pressing FILTER will toggle back to mode F0.

☐ EXTERNAL REFERENCE ☐

1. Press EXT REF to enter the External Reference mode (EXT REF LED will flash). The external reference voltage applied at the rear panel terminals will be displayed as long as EXT REF is held depressed. Release of the switch enters the 8502A into the External Reference mode.

2. For proper external reference operation; the resistance between SENSE LO on the front panel and external reference HI or LO on the rear panel must be less than 20 Kohms. Apply a direct connection between these two points to insure correct operation.

☐ REMOTE ☐

1. Use REMOTE to toggle between local and remote operation with either the RS 232 (Option –06) or or the Parallel (Option –07) Interface installed.

2. Use REMOTE to toggle into local only if in remote with the IEEE (Option –05) installed.

Figure 2-5. Modifiers (cont)

☐ RESUME ☐

Use RESUME to exit Manual or External Triggering modes.

☐ RESET ☐

Use RESET to put the 8502A back to the power on status:

1. V DC function.
2. 1000V range.
3. F0 filter.
4. 7 sample.
5. No other modifiers or memory modes in effect.
6. Memory entries lost. (Calibration Memory (Option –04) entries will not be lost.)

Figure 2-5. Modifiers (cont)

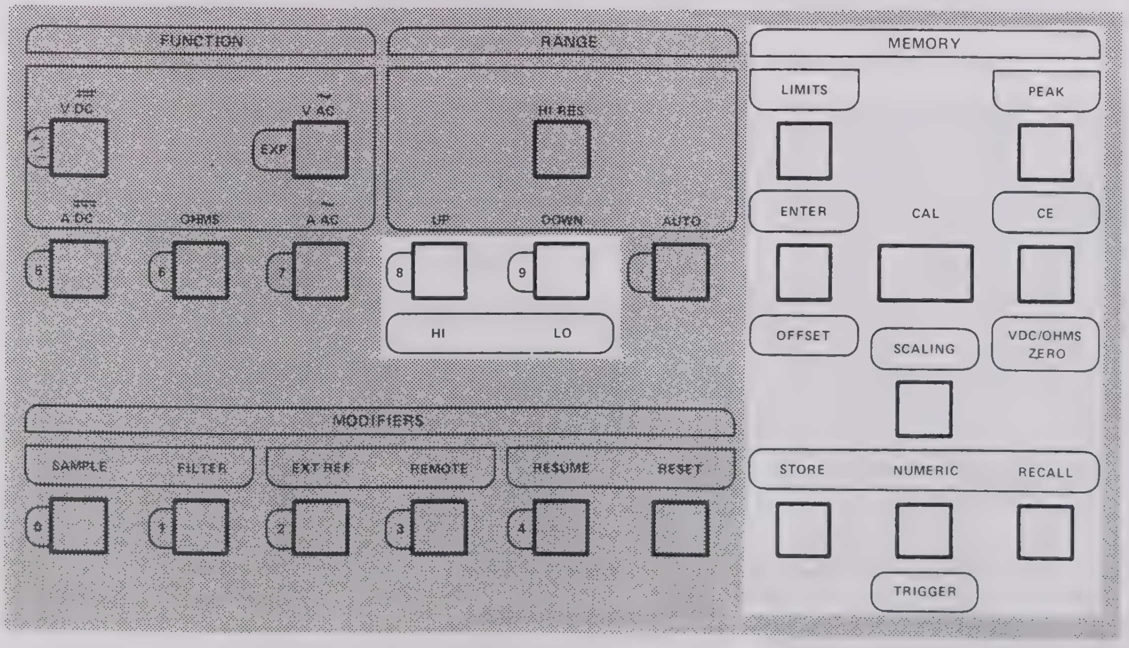

FUNCTION
RANGE
MEMORY
V DC
V AC
EXP
HI RES
A DC
OHMS
A AC
UP
DOWN
AUTO
5
6
7
8
9
HI
LO
LIMITS
PEAK
ENTER
CAL
CE
OFFSET
SCALING
VDC/OHMS ZERO
MODIFIERS
SAMPLE
FILTER
EXT REF
REMOTE
RESUME
RESET
0
1
2
3
4
STORE
NUMERIC
RECALL
TRIGGER

Figure 2-6. Memory

DISPLAY INDICATIONS WHEN PROGRAMMING THE 8502A

The display will respond to memory programming as in the following example:

PRESS	DISPLAY RESPONDS
STORE	"?"
NUMERIC	YES?
OFFSET	Go
(numbers)	1, 2, 3 . . .
ENTER	Return to normal display.

☐ LIMITS ☐

1. Select the Limit mode by depressing the LIMIT switch. A display of HI, LO, or PASS will indicate that the mode has been entered. Depress LIMIT a second time to exit the mode.

2. To store any displayed value as a limit value; use the following sequence:

   STORE → HI

   STORE → LO

   The value being entered will be displayed as long as HI or LO are held depressed. Release of either switch will enter the value as the respective limit. LIMIT must be separately depressed before or after entering values to enter the Limit mode.

3. To enter numeric values as limit values, press:

   STORE → NUMERIC → HI or LO → (value numbers) → ENTER

   LIMIT must be depressed to enter the mode.

4. To display the stored limits, press:

   RECALL → HI or LO → LIMIT

   The respective value will be displayed as long as LIMIT is held depressed.

☐ PEAK ☐

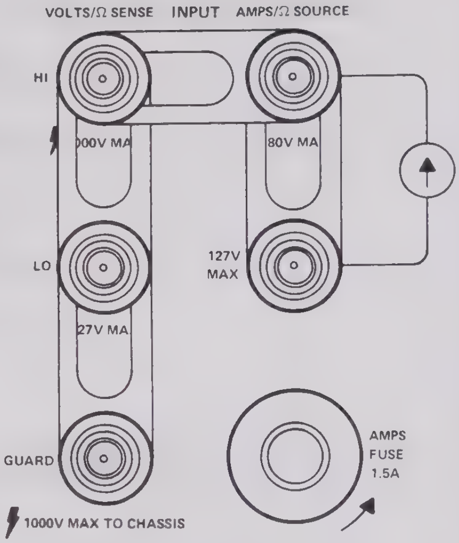
1. Press PEAK to toggle into or out of the Peak mode (PEAK LED will come on).

2. To display the readings recorded in this mode, use the following sequence:

   RECALL → HI or LO → PEAK

Figure 2-6. Memory (cont)

☐ VDC/OHM ZERO ☐



1. Correct for internal drift by shorting the input terminals as illustrated. Use a good quality, low thermal short. The instrument must be in the 100 mV or 10 ohm range.

   Now use the switches:

   STORE → VDC/OHM ZERO

   The value will be displayed as long as VDC/OHM ZERO is held depressed. The display will be zeroed once VDC/OHM ZERO is released.

2. To display the stored zero correction (for dc volts only), press:

   RECALL → VDC/OHM ZERO

   The value will be displayed as long as VDC/OHM ZERO is held depressed.

☐ OFFSET ☐

1. Enter the Offset mode by pressing OFFSET (OFFSET LED will come on). Exit this mode by again depressing OFFSET.

2. Store any currently displayed value with the following procedure:

   STORE → OFFSET

3. To enter a programmed numeric value as an offset, use the following procedure:

   STORE → NUMERIC → OFFSET → (numbers) → ENTER

4. To use OFFSET as a zeroing feature, first perform VDC/OHM ZERO. Then, short test leads used in dc volts or 2-wire ohms measurements. Press:

   STORE → OFFSET

   The value will be displayed as long as OFFSET is held depressed. Push OFFSET a second time to enter Offset mode.

Figure 2-6. Memory (cont)

☐ SCALING ☐

1. Press SCALING to enter this mode (SCALING LED will come on). Pressing the switch a second time will exit the mode.

2. Store any currently displayed value as a scaling factor by pressing:

   STORE → SCALING

   Read the value as long as SCALING is held depressed. Enter the mode by again depressing SCALING.

3. Enter a programmed numeric as a scaling factor by pressing:

   STORE → NUMERIC → SCALING → (numbers) → ENTER

   Press SCALING to enter the mode.

4. Display a stored scaling factor by pressing:

   RECALL → SCALING

☐ CAL ☐

1. Enter the Cal mode by sliding the CAL switch down (the CAL LED will flash). This switch will be found behind a small plastic cover which pulls out and hinges down. Use a small screwdriver or equivalent to slide the switch.

2. To enter calibration factors for each range and function, the optional Calibration Memory must be installed. Refer to Section 6 for applicable operating instructions.

☐ TRIGGER ☐

1. Press TRIGGER to activate both manual triggering mode and external triggering operation (–08A Option installed). The 8502A will now accept either:

   a. A manually triggered reading with each subsequent depression of TRIGGER, or

   b. An external trigger applied through the rear panel connector (part of Option –08A).

   Manual triggering from the front panel will take precedence if a simultaneous external trigger is received.

2. Exit manual/external triggering by pressing RESUME.

3. When you press a switch it is acted upon immediately, and the reading is aborted. Thus, if the instrument is in manual trigger and a switch is pressed during the reading, the 8502A will halt. It will then be necessary to press TRIGGER again to take the reading.

☐ CE ☐

Use this switch to clear a numeric entry prior to entry into memory.

Figure 2-6. Memory (cont)

☐ ENTER ☐

Use this switch to enter a numeric into memory.

☐ STORE ☐

Use to initiate a numeric entry sequence.

☐ RECALL ☐

Use to initiate recall and display of stored values.

CORRECTING ENTRY ERRORS

There are a number of methods to correct memory entry errors. Choices include staying in the entry sequence, exiting the sequence and retaining memory, or exiting the sequence and losing memory.

1. Stay in sequence: CE – erases only numbers before entry.
2. Exit sequence, retain memory: Generate any invalid switch sequence that will result in "Error C",
3. Exit sequence, lose memory: RESET or power interruption causes 8502A to assume V DC 1000V, F0, sample 7, blank memory (optional Calibration Memory not affected).

Figure 2-6. Memory (cont)

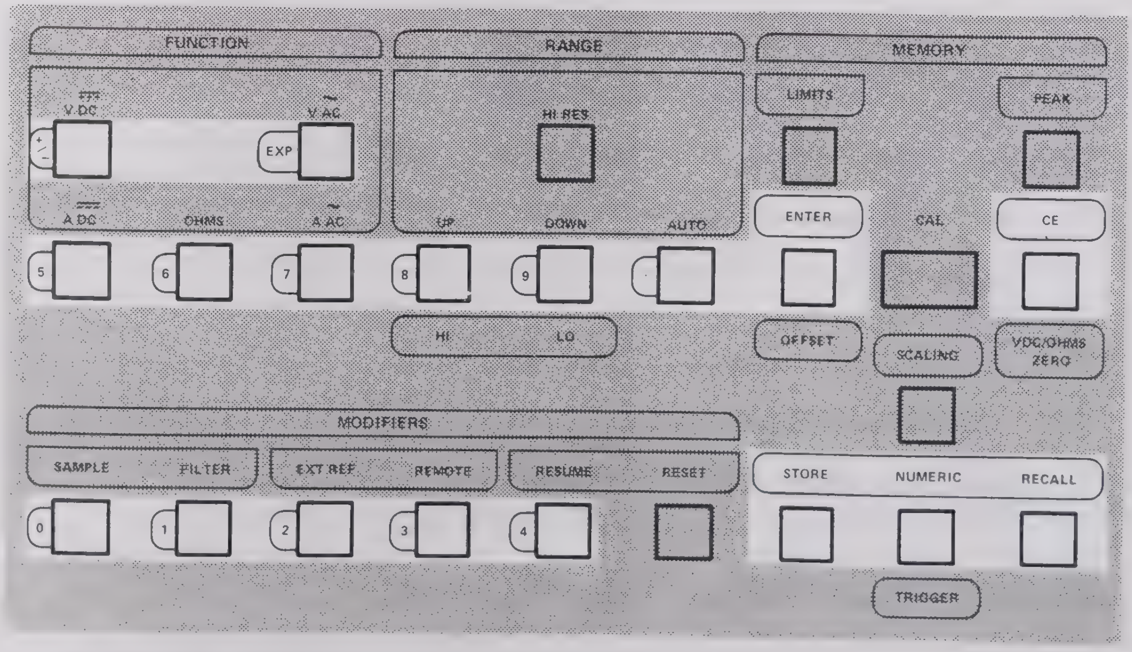

FUNCTION
RANGE
MEMORY
V DC
V AC
+
−
EXP
HI RES
LIMITS
PEAK
A DC
OHMS
A AC
UP
DOWN
AUTO
ENTER
CAL
CE
5
6
7
8
9
HI
LO
OFFSET
SCALING
VDC/OHMS ZERO
MODIFIERS
SAMPLE
FILTER
EXT REF
REMOTE
RESUME
RESET
STORE
NUMERIC
RECALL
0
1
2
3
4
TRIGGER

Figure 2-7. Numerics

☐ STORE ☐

Use the numeric sequence whenever entering a value (as in Offset) or a particular mode (as in Filter) into the 8502A's memory. Use the following procedural steps:

1. Initiate the numeric entry. Press:

STORE	("?" appears in display)
NUMERIC	(YES? appears in display)

2. Select the desired use for the numeric entry. Press:

OFFSET (SCALING FILTER, SAMPLE, HI or LO for LIMITS).	(Go appears in display)

3. Select the desired numbers. Numbers will appear in the display from left to right as they are entered.

NOTE: Press CE if an error is made during the following number, polarity and exponent entry steps. The 8502A will then display Go. Start entries again from this point.

   a. For Filter, enter the mode number (–, 0, 1, 2, or 3).

   b. For Sample, enter the exponent of 2 for samples averaged in each reading (0 through 17).

   c. For Offset, enter the number(s) for the offset factor.

   d. For Scaling, enter the number(s) for the scaling factor.

   e. For Limits (HI, LO), enter the numeric values desired.

4. To change the polarity of the numeric entry, press:

   +/–

5. To add an exponent to the numeric entry, press:

   EXP

6. To change polarity for the exponent, now press:

   +/–

7. To finalize storing of the entry and exit the numeric sequence, press:

   ENTER

8. The value is now stored. For Filter or Sample entries, the value is now also in effect. For Offset, Scaling or Limits, the value will not become effective until the appropriate mode is selected.

Figure 2-7. Numerics (cont)

2-82. Measurement Instructions

2-83. DC VOLTAGE (V DC)

2-84. Use the following procedure when measuring dc volts:

1. Select the VDC function.
2. The 8502A will go to autoranging. If desired, select manual ranging and one of the five available ranges (1000V, 100V, 10V, 1V, or 100 mV).
3. Perform DC Zero, if needed (100 mV range only).
4. Select desired modifiers and memory operations.
5. Connect the dc voltage to the HI and LO SENSE INPUT terminals.
6. A dc voltage reading should now appear in the display.

2-85. DC ZERO

2-86. For dc zeroing, use the following steps:

1. Select the V DC function and either autoranging or the 100 mV manual range.
2. Place a good quality, low thermal short across the HI and LO INPUT terminals.
3. Depress the STORE switch. "?" will appear in the display.
4. Depress the VDC/OHMS ZERO switch; value applied to input terminals will now be displayed as long as the switch is held depressed.
5. Release of the switch will activate V DC/Ohms Zero mode, applying the value read in step 4 as a zero reference for subsequent readings.

2-87. AC VOLTAGE (V AC)

2-88. Use the following procedure when measuring ac volts:

1. An AC Converter module must be installed (Option –01, or –09A).
2. Select the VAC function.
3. The 8502A will go to autoranging; manual ranging can be selected if necessary. There are four available ranges: 1000V, 100V, 10V, 1V.
4. Perform DC ZERO, if necessary. No additional zero procedure is needed for ac voltage.
5. Select desired modifiers and memory operations.
6. The slow filter (FILTER LED illuminated) must be selected for full accuracy below 400 Hz.
7. Connect the ac voltage to the HI and LO SENSE INPUT terminals.
8. The ac voltage should be read in the display.

2-89. AC VOLTAGE ON A DC LEVEL (V DC and V AC)

2-90. Use the following procecure when measuring ac and dc voltage:

1. The RMS AC Converter module must be installed.
2. Depress both V DC and V AC awitches simultaneously.
3. The 8502A will go to autoranging; manual ranging can be selected if necessary. There are four available ranges: 1000V, 100V, 10V or 1V.
4. Select desired modifiers and memory operations.
5. Connect the unknown voltage to the HI and LO SENSE INPUT terminals. The reading displayed will be the rms value of the two voltages combined.

2-91. DC CURRENT (A DC)

2-92. Use the following procedure when measuring dc current:

1. The Current Shunts module must be installed.
2. Select the A DC function.
3. The 8502A will go to autoranging; manual ranging can also be utilized to select one of five available ranges (100 uA, 1 mA, 10 mA, 100 mA, or 1A).
4. Select desired modifiers and memory operations.
5. Connect dc current to HI and LO INPUT SOURCE terminals.

2-93. AC CURRENT (A AC)

2-94. Use the following procedure when measuring ac current:

1. The Current Shunts module must be installed.

2. Select the A AC function.

3. Follow steps 3-5 listed for DC Current measurements.

2-95. OHMS

2-96. Use the following procedure for resistance measurements:

1. The Ohms Converter module must be installed.

2. Select the OHMS function.

3. The 8502A will go to autoranging; manual ranging can be selected if necessary. There are eight resistance ranges available: 100M, 10M, 1M, 100K, 10K, 1K, 100 and 10 ohms.

4. If necessary, perform the ohms zero procedure described below (10 ohm range only).

5. Select desired modifiers and memory operations.

6. Connect the unknown resistance to the HI and LO INPUT terminals (see Section 6 for 2-wire and 4-wire connection methods).

2-97. OHMS ZERO

2-98. For ohms zeroing, use the following steps:

1. The Ohms Converter module must be installed.

2. Select the Ohms function.

3. Select the 10 ohms range.

4. Short input terminals as described in zeroing instructions.

5. Depress the STORE switch; "?" will appear in the display.

6. Depress the V DC/OHMS ZERO switch; the value of residual resistance will be displayed for as long as the switch is held depressed.

7. Release of the zero switch will activate the Ohms Zero mode.

2-99. APPLICATIONS

2-100. The applications presented in Table 2-3 presuppose an initial power on or reset instrument status, i.e.,

1. V DC function.

2. 1000V range.

3. Sample – 7.

4. Filter – F0.

5. No stored values (excepting the Calibration Memory).

Table 2-3. Applications

STORING A DISPLAYED VALUE

$$\text{STORE} \longrightarrow \begin{cases} \text{OFFSET} \\ \text{VDC/OHM ZERO} \\ \text{SCALING} \\ \text{HI} \\ \text{LO} \end{cases}$$

APPLICATION 1

REQUIREMENT:	Monitor the stability of a power supply in terms of its deviation in volts from a present output of +5.03V.
METHOD:	Store the present output as an offset. Press: STORE → OFFSET → OFFSET Initial use of OFFSET places the displayed value into memory (value will be viewed as long as switch is held depressed). The second use of OFFSET places the instrument in Offset mode. The display will now read only the deviation from +5.03V.

Table 2-3. Applications (cont)

APPLICATION 2

REQUIREMENT: Monitor the stability of a power supply as a decimal ratio to its present reading of –20.08V. DC zeroing appears to be necessary.

METHOD: Perform V DC Zeroing for internal drift. Apply low thermal short between INPUT HI and LO (at the terminals). Press:

STORE → VDC/OHMS ZERO

The value stored will be displayed as long as VDC/OHMS ZERO is held depressed. Release of the switch will activate the Zero mode. Revise terminal interconnections for dc volts measurements. Connect the dc voltage.

Apply power supply reading of –20.08V as a scaling factor. Press:

STORE → SCALING → SCALING

Initial use of SCALING places the displayed value (which is seen as long as the switch is held depressed) into memory. The second use of SCALING places the 8502A into Scaling mode.

Display will now yield the ratio of subsequent readings to the scaling factor, e.g., an input of 22.08V yields a ratio of:

$$\frac{22.088}{20.08} = 1:1$$

STORING A NUMERIC ENTRY

$$\text{STORE} \rightarrow \text{NUMERIC} \rightarrow \left\{ \begin{array}{llll} \text{OFFSET} & & & \\ \text{SCALING} & \rightarrow \text{(value number)} & \rightarrow & \text{ENTER} \\ \text{HI} & & & \\ \text{LO} & & & \\ \text{FILTER} & \rightarrow (-, 0, 1, 2, 3) & \rightarrow & \text{ENTER} \\ \text{SAMPLE} & \rightarrow \text{(0 thru 17)} & \rightarrow & \text{ENTER} \end{array} \right.$$

APPLICATION 3

REQUIREMENT: Determine which of a group of power supplies have a tolerance of 15V ± 100 mV.

METHOD: Set high and low limits. Press:

STORE → NUMERIC → HI → 1 → 5 → . → 1 → ENTER

STORE → NUMERIC → LO → 1 → 4 → . → 9 → ENTER

Select LIMITS. The 8502A will now display "HI", "LO", or "PASS" for each power supply.

Table 2-3. Applications (cont)

APPLICATION 4	
REQUIREMENT:	For a group of 20V power supplies, determine the deviation in volts.
METHOD:	Offset the displayed reading by 20. Press: STORE → NUMERIC → OFFSET → 2 → 0 → ENTER Select OFFSET. Any value displayed now will equal the deviation from 20V.

APPLICATION 5	
REQUIREMENT:	Display the input error voltage for an operational amplifier by measuring the dc output error. Gain = 2.6847×10^4.
METHOD:	Divide the measured dc output error by a scaling factor (the op amp gain). Press: STORE → NUMERIC → SCALING → 2 → . → 6 → 8 → 4 7 → EXP → 4 → ENTER Select SCALING. The 8502A will now divide the measured input by the gain of the op amp and display the input error voltage.

APPLICATION 6	
REQUIREMENT:	Make a series of measurements in a noisy environment. Speed of measurement is not important. Display only the deviation in volts.
METHOD:	Allow for extra settling between readings. Press: STORE → NUMERIC → FILTER → 3 → ENTER Increase digital filtering (average more samples per reading). Press: STORE → NUMERIC → SAMPLE → 9 → ENTER Offset by the nominal output (e.g., 15V). Press: STORE → NUMERIC → OFFSET → 1 → 5 → ENTER Select OFFSET

Table 2-3. Applications (cont)

RECALLING

$$\text{RECALL} \rightarrow \left\{ \begin{array}{l} \text{OFFSET} \\ \text{VDC/OHMS ZERO} \\ \text{EXT REF} \\ \text{SAMPLE RATE} \\ \text{SCALING} \\ \text{FILTER} \\ \text{PEAK} \\ \left.\begin{array}{l} \text{HI} \\ \text{LO} \end{array}\right\} \rightarrow \left\{\begin{array}{l} \text{PEAK} \\ \text{LIMIT} \end{array}\right. \end{array}\right.$$

APPLICATION 7

REQUIREMENT:	Determine the highest and lowest readings encountered in measuring a group of 28V power supplies.
METHOD:	Press PEAK to record measurement extremes. When required measurements are complete, use the following sequence to recall high and low values. Press: RECALL → LO → PEAK RECALL → HI → PEAK (Hold PEAK in to read the recorded values.)

Section 3

Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual describes the theory of operation for the 8502A mainframe, which includes the modules necessary for DC Volts and DC Ratio measurements. Block Diagram descriptions give an overview of the operation of the modules and an explanation of the bus structure. Circuit Analyses give a more detailed description of the circuitry. Optional modules are described in Sect. 6.

3-3. BLOCK DIAGRAM DESCRIPTION

3-4. Bus Structure

3-5. The 8502A is constructed with a bus architecture similar to a computer. Figure 3-1 is an overall block diagram of the instrument with optional modules drawn in dashed lines. Figure 3-2 is a block diagram illustrating signal flow. A microprocessor-based controller module controls information flow on the three buses. The controller sets up each of the analog modules for a measurement by addressing the modules as memory locations. An unguarded digital interbus is used to connect the controller to the front panel and to digital option modules such as the calibration memory and a remote I/O (input/output) interface.

3-6. The unguarded digital bus consists of the following lines:

1. Address/Control (IC) lines –7.
2. Bidirectional data (ID) lines –8.
3. Real time (RT) lines –7.
4. Handshake lines (INT–interrupt, ACK–acknowledge, INA–interrupt acknowledge).
5. Power Supply lines.

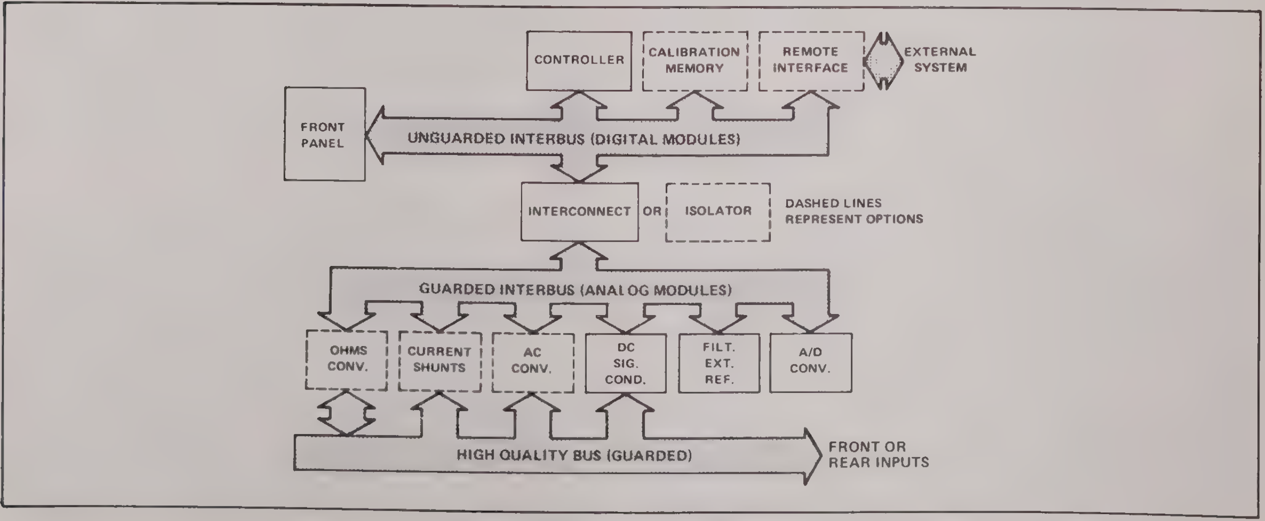

CONTROLLER
CALIBRATION MEMORY
REMOTE INTERFACE
EXTERNAL SYSTEM
FRONT PANEL
UNGUARDED INTERBUS (DIGITAL MODULES)
INTERCONNECT
OR
ISOLATOR
DASHED LINES REPRESENT OPTIONS
GUARDED INTERBUS (ANALOG MODULES)
OHMS CONV.
CURRENT SHUNTS
AC CONV.
DC SIG. COND.
FILT. EXT. REF.
A/D CONV.
HIGH QUALITY BUS (GUARDED)
FRONT OR REAR INPUTS

Figure 3-1. 8502A Block Diagram

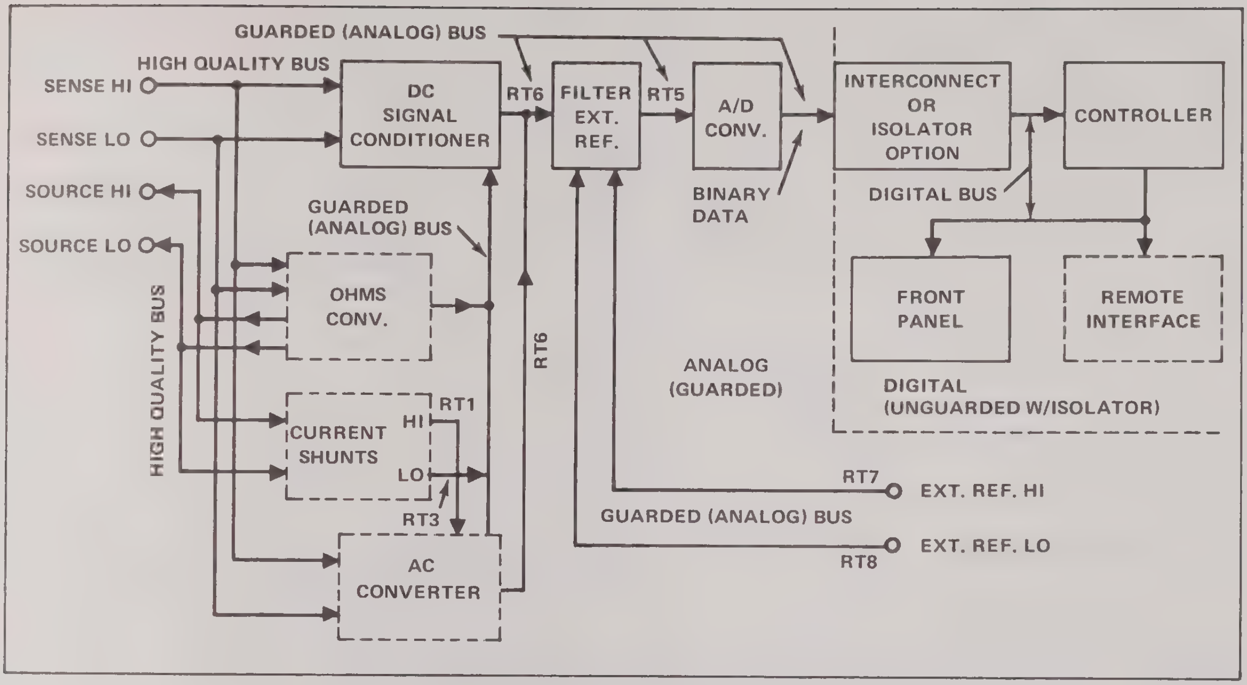

GUARDED (ANALOG) BUS
HIGH QUALITY BUS
SENSE HI
SENSE LO
SOURCE HI
SOURCE LO
DC SIGNAL CONDITIONER
RT6
FILTER EXT. REF.
RT5
A/D CONV.
INTERCONNECT OR ISOLATOR OPTION
CONTROLLER
BINARY DATA
DIGITAL BUS
GUARDED (ANALOG) BUS
OHMS CONV.
HIGH QUALITY BUS
RT6
FRONT PANEL
REMOTE INTERFACE
ANALOG (GUARDED)
DIGITAL (UNGUARDED W/ISOLATOR)
RT1
HI
CURRENT SHUNTS
LO
RT3
RT7
EXT. REF. HI
GUARDED (ANALOG) BUS
EXT. REF. LO
RT8
AC CONVERTER

Figure 3-2. 8502A Analog Signal Flow

3-7. The guarded bus connects the controller to the analog modules through the Bus Interconnect Board or through the optional Isolator module; the Isolator must replace the Interconnect Board if an optional remote interface is installed. The guarded bus consists of the following lines:

1. Address/Control (IC) lines –7.
2. Bidirectional data (ID) lines –8.
3. Real time lines –9.
4. Handshake line (ACK) –1.
5. Power Supply lines.

3-8. The address, handshake, and data lines of the two buses serve the same functions. The real time and power supply lines may have differing functions. For example, the RT lines in the unguarded bus are unused except for RT5 (frequency reference). The RT lines in the guarded bus form an analog bus which carries all the conditioned and converted analog signals between the analog modules. The external reference input lines are part of the analog bus (RT7 and RT8). Logic supply lines (Vcc and Vss) will be different in the two busses if an isolator option is installed. In the guarded bus, Vcc and Vss are always –15V and –20V with respect to analog common. In the unguarded bus with an interconnect pcb installed Vcc and Vss are diode coupled to the guarded bus. But with the isolator option installed, Vcc and Vss are isolated from analog common.

3-9. The high quality bus consists of lines connecting the input switch (Sense HI and LO, source HI and LO, Guard, Ohms Guard) to the signal conditioning and converting modules (AC converters, Ohms converter, etc.). Ohms guard is only available through the rear inputs.

3-10. Controller

3-11. Under the direction of the software program, the controller addresses and sets up each of the modules necessary to perform a function. Two types of addresses are used: direct and indirect. An indirect address requires a previous direct address to set up the indirect address response logic. Data transfers are accomplished with a handshake between the address (IC) lines and the acknowledge (ACK) line. When the controller addresses a module, it places data on the data (ID) lines or receives data from the addressed module. The addressed module must respond with an ACK signal signifying that it is receiving or sending data.

3-12. The controller directs the R^2 A/D converter in taking a sample and receives the sample data from the converter. The controller stores range and function information for application to the sample data. Using the arithmetic capability of the microprocessor, the software processes the data to arrive at a binary 2's complement number which represents the polarity and value of the measurement. This number is made available to an optional remote interface either as is or after further processing to ASCII code. The number is further processed by the controller for application to the front panel display in a seven segment LED format.

3-13. The software program consists of two parallel processes. A background process (Figure 3-3) is responsible for interrupt driven activities such as updating the display digits and directing the A/D converter in taking a sample. The foreground process (Figure 3-4) is responsible for the measurement cycle including accumulating data from the background process and performing required calculations.

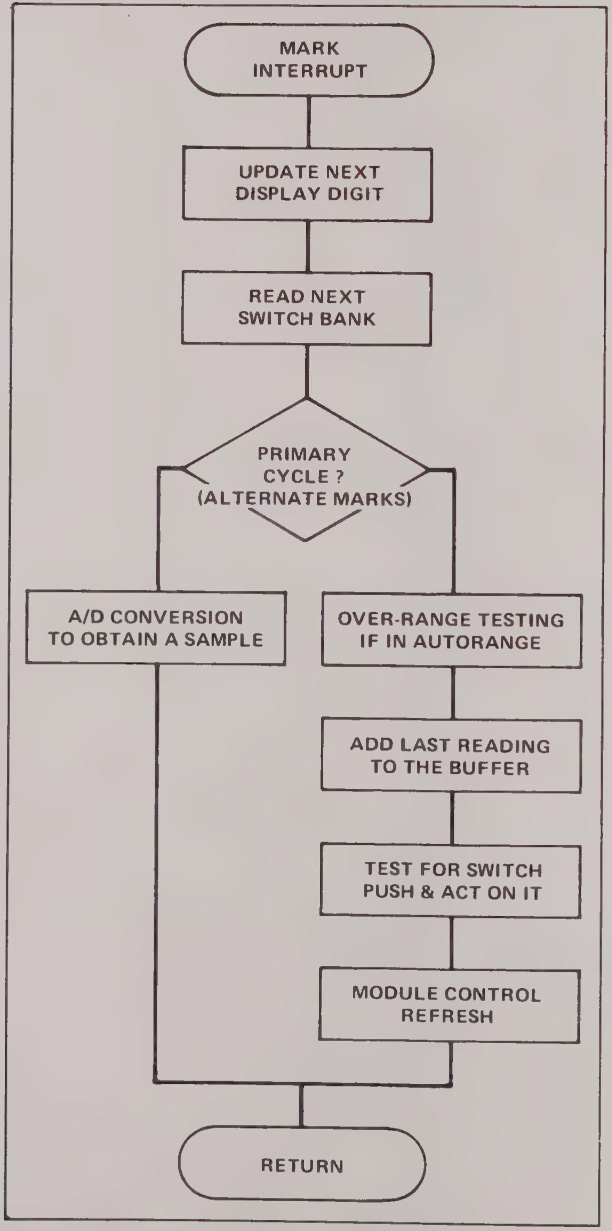

MARK INTERRUPT
UPDATE NEXT DISPLAY DIGIT
READ NEXT SWITCH BANK
PRIMARY CYCLE ? (ALTERNATE MARKS)
A/D CONVERSION TO OBTAIN A SAMPLE
OVER-RANGE TESTING IF IN AUTORANGE
ADD LAST READING TO THE BUFFER
TEST FOR SWITCH PUSH & ACT ON IT
MODULE CONTROL REFRESH
RETURN

Figure 3-3. Background Software Process

3-14. The controller is structured around the Intel 8080 microprocessor. Figure 3-5 is a block diagram of the controller module. Hardware control functions have been minimized by careful software design. Sequences of events are timed from two sources. Basic operations of the microprocessor are run from a 1.7 MHz clock. The other source is generated by shaped line frequency pulses, which are applied to a phase-locked loop. The phase-locked loop multiplies the line frequency by eight. This signal is used to generate mark interrupts which time the background process.

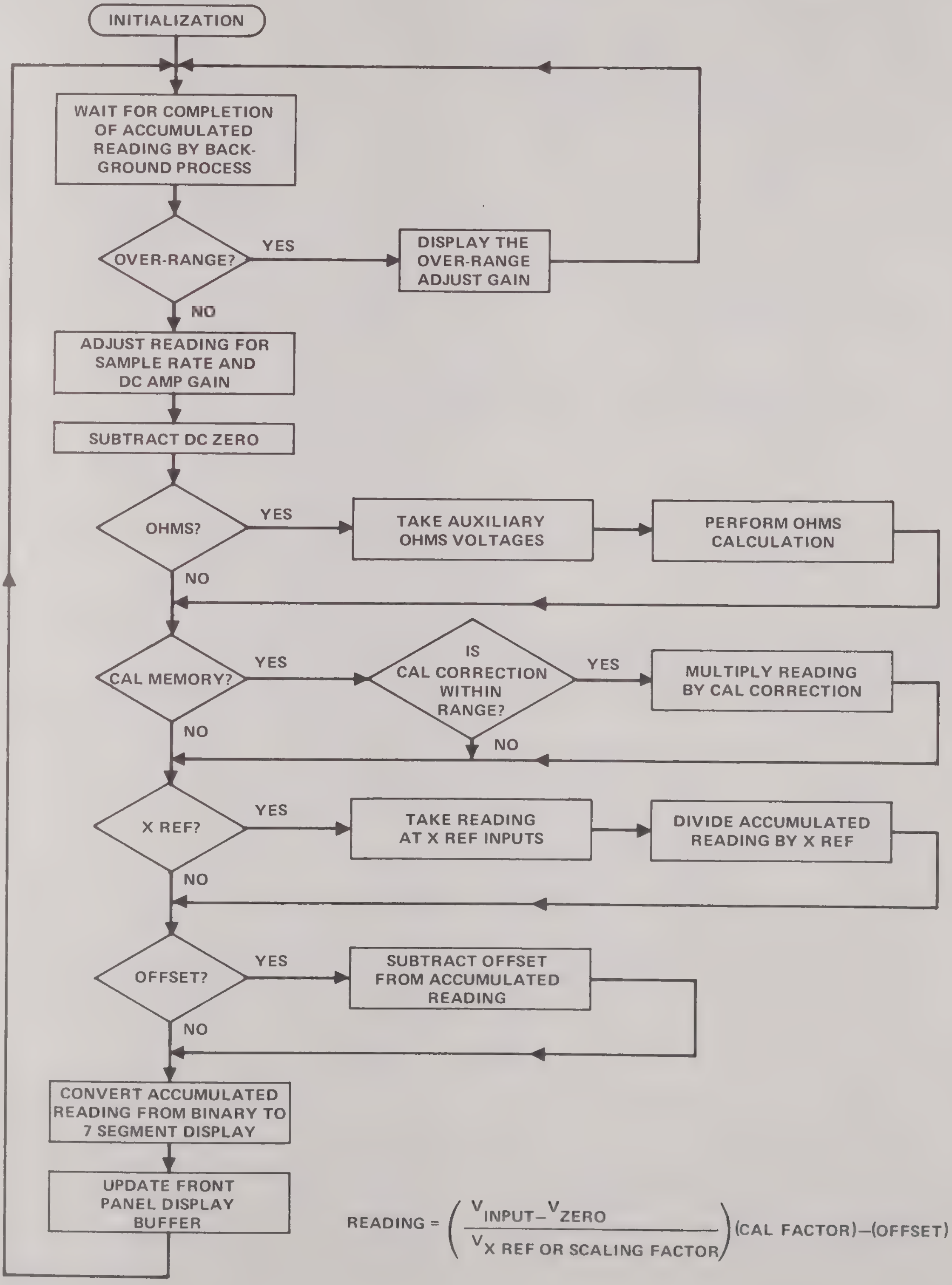
3-15. Software for the 8502A is stored in five ROM's. These read only memories are mounted on a "piggy-back" board, which is connected to the main controller pcb at the socket for U25. Four RAMs (random access memory) are used for temporary storage of data by the microprocessor. Data lines (DB0-DB7) are used for bidirectional data flow. Address lines (A0-A15) determine the source or storage location of data. Since other modules of the 8502A system are addressed as memory locations, address and data I/O controls are used for access to the external bus structure.

3-16. Interrupts are used to divert the microprocessor from the main program to service other soutines. Interrupts are synchronized to an appropriate time in the microprocessor cycle through interrupt control, where assigned priorities vector module identity data onto the data bus. Module identity data words direct the microprocessor to the memory location containing the next instruction. Two interrupts are internally generated: ACK INT and MARK INT (priorities one and six respectively). ACK INT is generated when an acknowledge signal is not returned. MARK INT is used to synchronize A/D samples and display digit updates to the line frequency.

3-17. An interrupt may be externally requested by pulling the INT line low. When the microprocessor is ready to accept the interrupt, the interrupt acknowledge (INA) signal is generated. The requesting module must respond with an ACK and a data bit (on ID1-ID4) which is used as a priority vector by INT CONTROL.

3-18. Two types of resets may occur: software and hardware. Software resets are a result of front panel or remote requests. Hardware resets occur at power up or power down. Line frequency pulses from RT5 are sensed by the reset logic. At power up the reset signal assures that the microprocessor will start from program location zero. At power down the reset signal assures that the controller will not call up wrong modules.

3-19. The microprocessor control logic is responsible for latching up a status word at the beginning of each instruction cycle and for telling the microprocessor when to enter and exit wait states. Microprocessor sequences are divided into machine states (one clock period, 588 nsec), machine cycles (from three to five states) and instruction cycles (from one to five machine cycles). Status words are used to control and synchronize data I/O, memory read/write, and some of the interrupt control signals. The microprocessor must be instructed to enter a wait state after addressing an external module and after being interrupted to allow the external module time to respond.


INITIALIZATION
WAIT FOR COMPLETION OF ACCUMULATED READING BY BACKGROUND PROCESS
OVER-RANGE?
YES
DISPLAY THE OVER-RANGE ADJUST GAIN
NO
ADJUST READING FOR SAMPLE RATE AND DC AMP GAIN
SUBTRACT DC ZERO
OHMS?
YES
TAKE AUXILIARY OHMS VOLTAGES
PERFORM OHMS CALCULATION
NO
CAL MEMORY?
YES
IS CAL CORRECTION WITHIN RANGE?
YES
MULTIPLY READING BY CAL CORRECTION
NO
NO
X REF?
YES
TAKE READING AT X REF INPUTS
DIVIDE ACCUMULATED READING BY X REF
NO
OFFSET?
YES
SUBTRACT OFFSET FROM ACCUMULATED READING
NO
CONVERT ACCUMULATED READING FROM BINARY TO 7 SEGMENT DISPLAY
UPDATE FRONT PANEL DISPLAY BUFFER

$$\text{READING} = \left(\frac{V_{\text{INPUT}} - V_{\text{ZERO}}}{V_{\text{X REF OR SCALING FACTOR}}}\right)(\text{CAL FACTOR}) - (\text{OFFSET})$$

Figure 3-4. Foreground Software Process

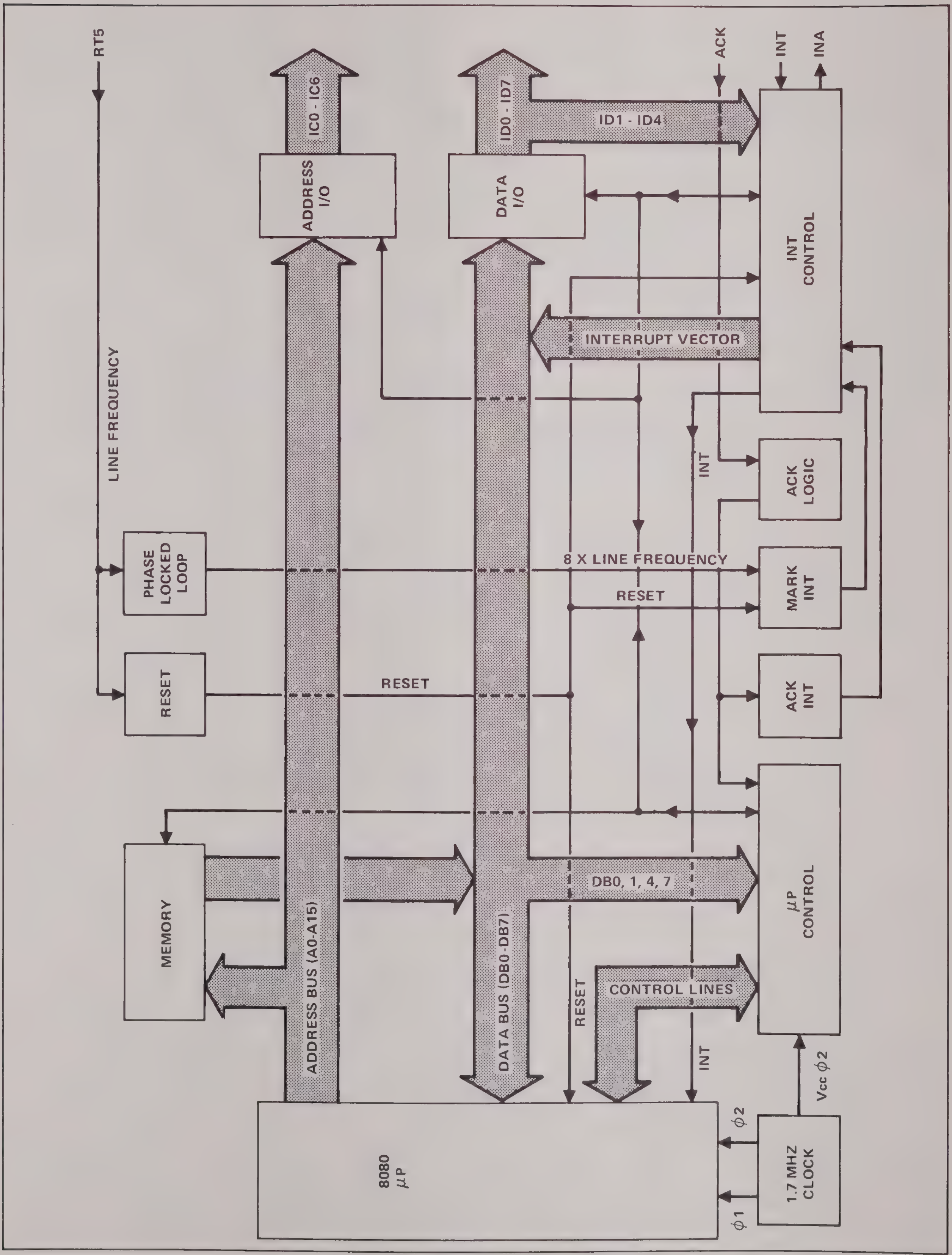

RT5
LINE FREQUENCY
PHASE LOCKED LOOP
RESET
MEMORY
ADDRESS BUS (A0-A15)
ADDRESS I/O
IC0 - IC6
DATA I/O
ID0 - ID7
ID1 - ID4
DATA BUS (DB0-DB7)
ACK
INT
INA
INT CONTROL
INTERRUPT VECTOR
INT
ACK LOGIC
8 X LINE FREQUENCY
RESET
MARK INT
RESET
ACK INT
DB0, 1, 4, 7
μP CONTROL
CONTROL LINES
RESET
INT
Vcc φ2
φ2
φ1
1.7 MHZ CLOCK
8080 μP

Figure 3-5. Controller Block Diagram

3-20. Front Panel

3-21. The front panel serves as an interface between the operator and the 8502A controller. The display is multiplexed by the controller by means of addressing the front panel for each digit. One direct address, two indirect addresses, and the accompanying data determine which digit or annunciator and which segments will light. An indirect address requires a previous, valid direct address to set up the indirect response. Another direct address enables the switch matrix to be read to determine if any function changes are desired. The cycle of updating each digit and annunciator and reading the switch matrix requires approximately 28 msec and is a continual cycle. Input terminals, J1-J5, are physically located on the front panel but have no electrical interaction with the front panel.

3-22. DC Signal Conditioner

3-23. DC signals from either the input terminals or optional signal conditioners (Ohms or Current Shunts) are routed through the DC Signal Conditioner to be brought within the range of the A/D Converter (± 20V). Figure 3-6 is a block diagram of the DC Signal Conditioner. For ease in arithmetic manipulations in the microprocessor, all gains and attenuations in the 8502A are powers of eight. Gain or attenuation factors are selected by the microprocessor addressing the module. Data from the data bus is latched into the control circuitry and used to select relays in the attenuator and switches in the amplifier feedback circuit. The combination of the attenuator and feedback-controlled amplifier give gain or attenuation factors of one, eight, or sixty-four.

3-24. Active Filter

3-25. The purpose of the Active Filter module is to multiplex dc signals to the A/D Converter and to switch analog filters into the signal conditioner inputs. Figure 3-7 is a block diagram of the Filter/External Reference module. Five filter modes may be selected from the front panel. For

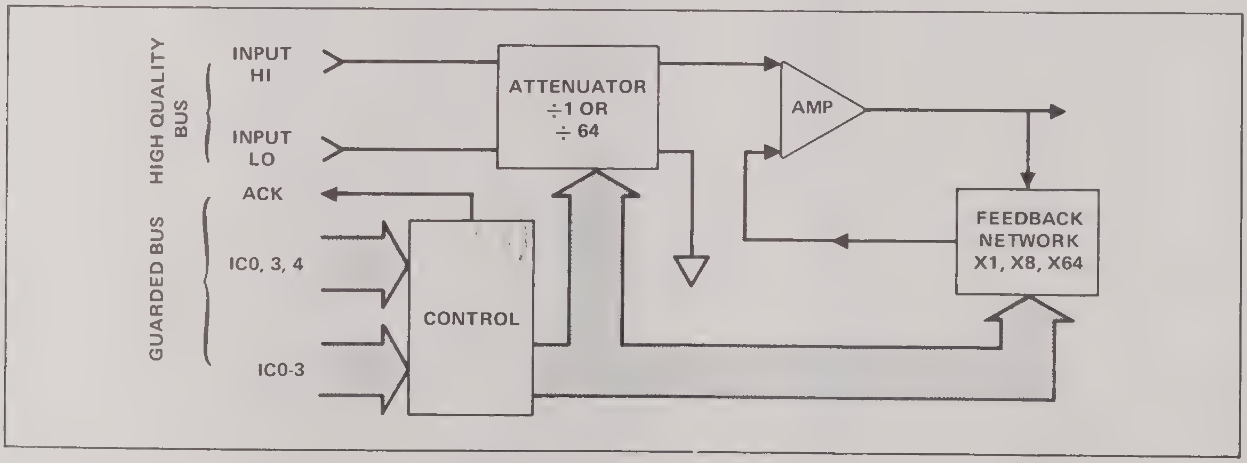

HIGH QUALITY BUS
INPUT HI
INPUT LO
GUARDED BUS
ACK
IC0, 3, 4
IC0-3
ATTENUATOR ÷1 OR ÷ 64
AMP
FEEDBACK NETWORK X1, X8, X64
CONTROL

Figure 3-6. DC Signal Conditioner Block Diagram

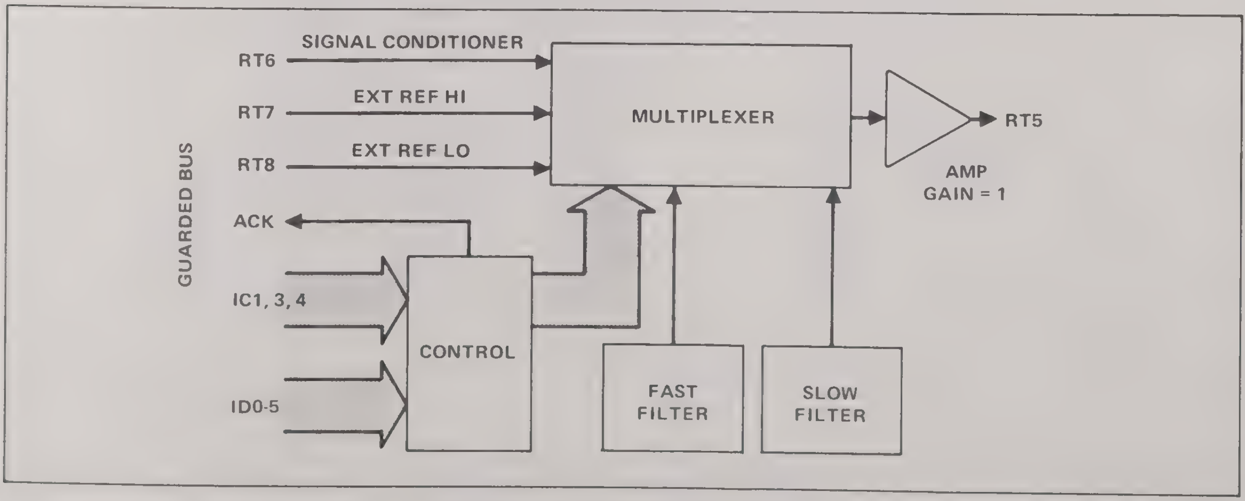

GUARDED BUS
RT6
SIGNAL CONDITIONER
RT7
EXT REF HI
RT8
EXT REF LO
ACK
IC1, 3, 4
ID0-5
MULTIPLEXER
RT5
AMP GAIN = 1
CONTROL
FAST FILTER
SLOW FILTER

Figure 3-7. Active Filter Block Diagram

external reference measurements, the signal conditioner input, the External Reference HI input and the External Reference LO input are multiplexed to the A/D Converter. Samples are taken of each input and arithmetically manipulated by the Controller to arrive at a reading. Outputs from the optional AC converter modules are applied to the Active Filter module, bypassing the DC Signal Conditioner.

3-26. Fast R^2 A/D Converter

3-27. The Fast R^2 A/D Converter employs Fluke's patented recirculating remainder (R^2) technique for converting a dc input signal into a binary, bit-serial data stream. The R^2 technique has been modified for microprocessor control. Obtaining a sample is a five-step process. Each step consists of a decision period of five decisions and a subtraction period. Set-up of the converter, decisions, and reset are initialized by the Controller addressing the A/D Converter. Figure 3-8 is a block diagram of the R^2 A/D Converter.

3-28. During the first step, the input signal is applied to the Summing Node. The polarity of the input is detected and the resulting bit of information is transmitted to the Controller. On the basis of the returned polarity, the A/D module selects which reference polarity is required: positive for negative inputs, negative for positive inputs. The first of five precision currents is switched into the Summing Node and a polarity bit returned. If the polarity is changed, the first current is switched off. If not, it is left on. Then the next current is switched into the Summing Node and another polarity bit returned. Another decision is made and so on until all five currents have been switched into the Summing Node and five decisions have been made. This completes the first decision period. The five precision currents are related by powers of two. The fifth current has a resolution of thirty-two.

3-29. Following the decision period is a subtraction period. Feedback through the Remainder Storage nulls whatever remainder was left after the five currents have been switched into the summing node. The remainder is amplified by 16 in the Remainder Amp and is stored on a capacitor in Remainder Storage. This completes the first step. The input is now switched out of the Summing Node and the amplified remainder switched in for the next step. There are two remainder channels in Remainder Storage and they are alternated in the four subsequent steps. Since the fifth current has a resolution of thirty-two and the Remainder Amp has a gain of 16, the first bit of a step has the same significance as the last bit of the previous step.

3-30. Of the five steps required to complete a sample, the first uses the input signal for decision and subtraction periods. The four subsequent steps alternate remainder channels to use the amplified remainder of the preceding step for decision and subtraction periods. Polarity bits

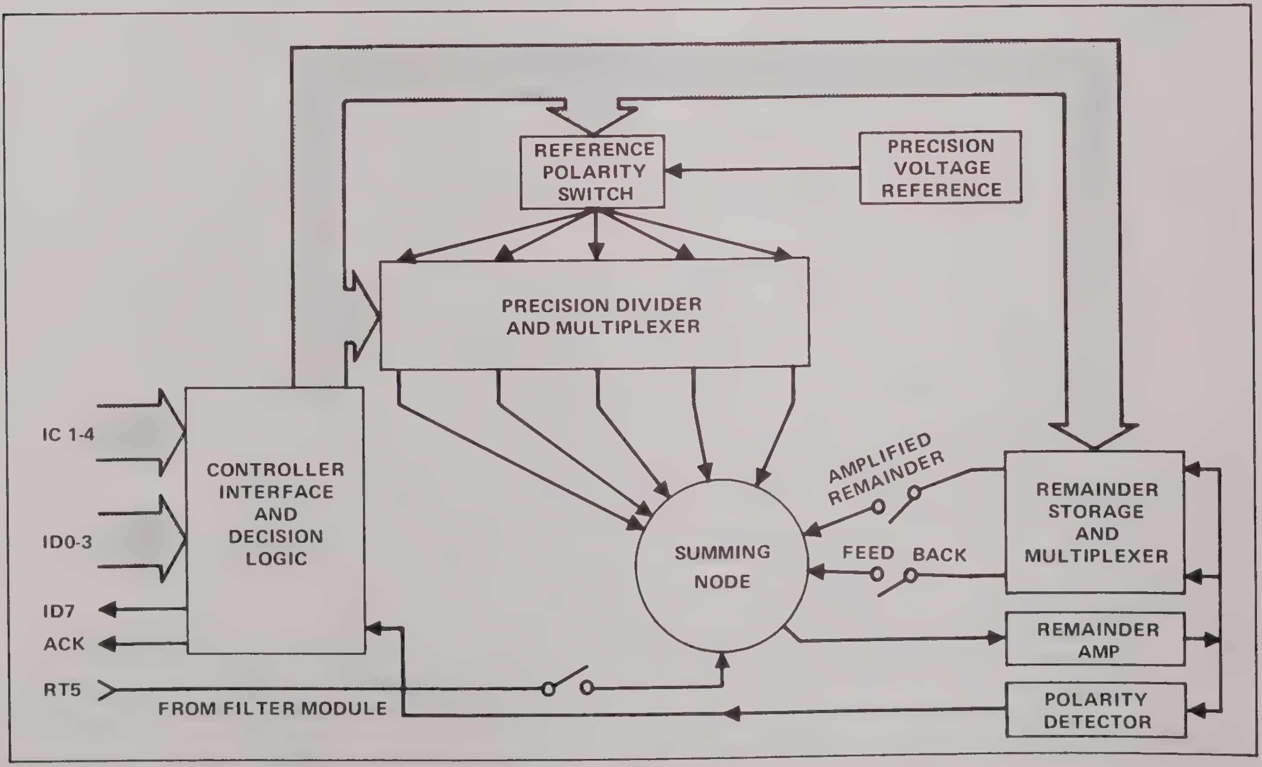

REFERENCE POLARITY SWITCH
PRECISION VOLTAGE REFERENCE
PRECISION DIVIDER AND MULTIPLEXER
IC 1-4
ID0-3
ID7
ACK
RT5
CONTROLLER INTERFACE AND DECISION LOGIC
FROM FILTER MODULE
SUMMING NODE
AMPLIFIED REMAINDER
FEED BACK
REMAINDER STORAGE AND MULTIPLEXER
REMAINDER AMP
POLARITY DETECTOR

Figure 3-8. R^2 A/D Converter Block Diagram returned at each decision are accumulated by the Controller and assembled into a 24-bit word describing the polarity and magnitude of the input.

3-31. CIRCUIT ANALYSIS

3-32. Introduction

3-33. Detailed circuit descriptions for each module in the standard 8502A mainframe will be presented in the following paragraphs. Optional modules are covered in Section 6. Block Diagram Description should be read first to get an understanding of the overall functioning of the instrument. Simplified schematic diagrams are located in Section 8 (Section 6 for optional modules). Table 3-1 is a list of mnemonic definitions used in the Controller schematic.

3-34. Controller

3-35. TIMING

3-36. The 8080 microprocessor requires two 12V clock inputs whose phase relationship must fall within certain limits (Figure 3-9). The period of the ϕ1 clock (588 nsec) governs the duration of a machine state (3 to 5 states required for a machine cycle, 1 to 5 machine cycles required for an instruction cycle). A 1.7 MHz crystal oscillator is RC coupled through buffers and gates to provide the two-phase clock signal. R1 controls the positioning of the ϕ1 clock pulse (with respect to time) during the ϕ2 pulse. The ϕ2 clock pulse is inverted and translated to 5 volt TTL levels for other timing functions in the control circuitry.

3-37. Shaped line pulses are applied to a phase-locked loop (U26) which runs at 8 times the line frequency 480 Hz for 60 Hz line, 400 Hz for 50 Hz line). The output of U26 is divided by 8 (U34) and applied to a phase comparator (U26). Line synchronization is achieved using the output of the phase-locked loop to time the internal interrupt, MARK INT.

3-38. ADDRESS and DATA BUSSES

3-39. Sixteen address lines are used for addressing memory locations and external modules. Refer to the Controller schematic in Section 8. Internal scratch pad memory locations use A0-A7, with A8, 9, 11, 12, 13 decoded as a RAM chip select. Internal ROM locations use A0-A10, A11, 12, 13 decoded as a ROM chip select. ROM/RAM select uses A14 for RAM (high for RAM). External addresses use A8-A14 with A15 used as external/internal select (high for external). These address lines are inverted when driving the IC lines on the Interbus. The data bus is eight lines (DB0-7) connected directly to memory and to the external data bus (ID0-7) through tristate I/O buffers.

Table 3-1. Mnemonic Definitions

ACK	— acknowledge
ACK LAT	— acknowledge late
AR	— analog return
DB	— data bus
DBIN	— data bus input signal (from μP)
DLD ACK	— delayed ACK
EN INT	— enable interrupt
HLDA	— hold acknowledge
IB ADX	— interbus address
IBIN	— interbus input signal
IC	— interbus control
ID	— interbus data
IINT	— internal interrupt
INA	— interrupt acknowledge (from controller)
INT	— interrupt
INTA	— Interrupt acknowledge (status word from μP)
INTE	— interrupt enable (from μP)
MEM RD	— memory read
MS ADDR BYTE	— memory select address byte
ϕ1	— clock pulse
ϕ2	— clock pulse
ϕLL	— phase-locked loop
RAM	— random access memory
ROM	— read only memory
RRDY	— reset ready
RST	— reset
RT	— real time
R/$\overline{W}$	— read/$\overline{\text{write}}$
μP	— microprocessor
VA	— analog supply voltage
V_{CC} ϕ2	— 5V clock pulse
V_{DD} ϕ2	— 12V clock pulse
SRDY	— set ready
SYN IINT	— synchronized internal interrupt
TTL PU	— TTL pull-up
WO	— write out
WR	— write

3-40. RESET

3-41. Shaped line frequency pulses are applied to U36 and U34 to provide a reset on power up or power down (Figure 3-10). U36 is a retriggerable one-shot multivibrator which is cleared on power up by Delayed Vcc. Clearing U36 sets U35 to the Reset condition. After the clear on U36 is removed (Delayed Vcc high), U34 clocks U35 out of the reset condition on the eighth line pulse. At power down, U36 changes state at a time determined by R18 and C22, setting U35 to the reset state.

3-42. STATUS LATCH

3-43. During the first state of every machine cycle, the microprocessor sends a status word out on the data bus. This is at the same time and duration as the SYNC output. SYNC ϕ2 clocks the status word into a hex "D" latch, U18. Outputs from U18 (Figure 3-11) are used in various portions of the control circuitry.

3-44. WAIT LOGIC

3-45. When the microprocessor addresses an external module (A15 high) or is interrupted, the WAIT logic causes the microprocessor to enter a wait state by pulling the ready (RDY) line low (Figure 3-12). Set Ready (SRDY), normally high, is pulled low to exit the wait state. Reset ready (RRDY), normally low, goes high to enter the wait state. For an external address, A15 TTL is high; therefore RRDY will go high at SYNC TTL (derived from the microprocessor). For interrupts, the interrupt enable (INTE) signal is inverted for application to U8. INTE enables INT and is removed before INT falls low (due to an RC delay in the INT CONTROL circuit) so the INT and INTE are high long enough to clock U1 for a wait signal.

3-46. Three possible combinations will cause the microprocessor to exit a wait state. If an ACK signal is missing, ACK INT TTL will pull SRDY low. For external addresses, and external interrupts, A15 + INTA and ACK LAT will pull SRDY low. For internal interrupts SYN IINT and INTA

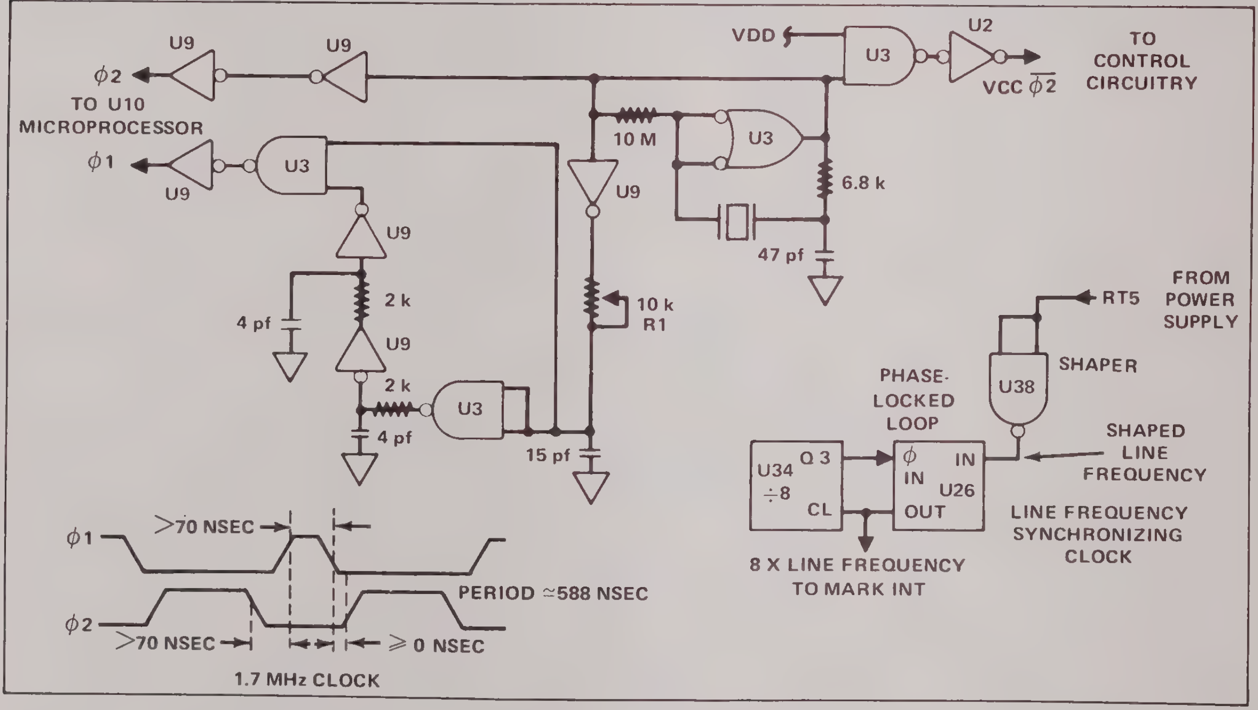

U9
U9
ϕ2
TO U10
MICROPROCESSOR
ϕ1
U9
U3
U9
4 pf
2 k
U9
2 k
4 pf
U3
15 pf
10 M
U9
10 k
R1
VDD
U3
U2
VCC $\overline{\phi 2}$
TO CONTROL CIRCUITRY
U3
6.8 k
47 pf
RT5
FROM POWER SUPPLY
SHAPER
U38
PHASE-LOCKED LOOP
U34
÷8
Q 3
CL
ϕ IN
IN
U26
OUT
SHAPED LINE FREQUENCY
LINE FREQUENCY SYNCHRONIZING CLOCK
8 X LINE FREQUENCY TO MARK INT
ϕ1
>70 NSEC
PERIOD ≃588 NSEC
ϕ2
>70 NSEC
≥ 0 NSEC
1.7 MHz CLOCK

Figure 3-9. Timing Circuits

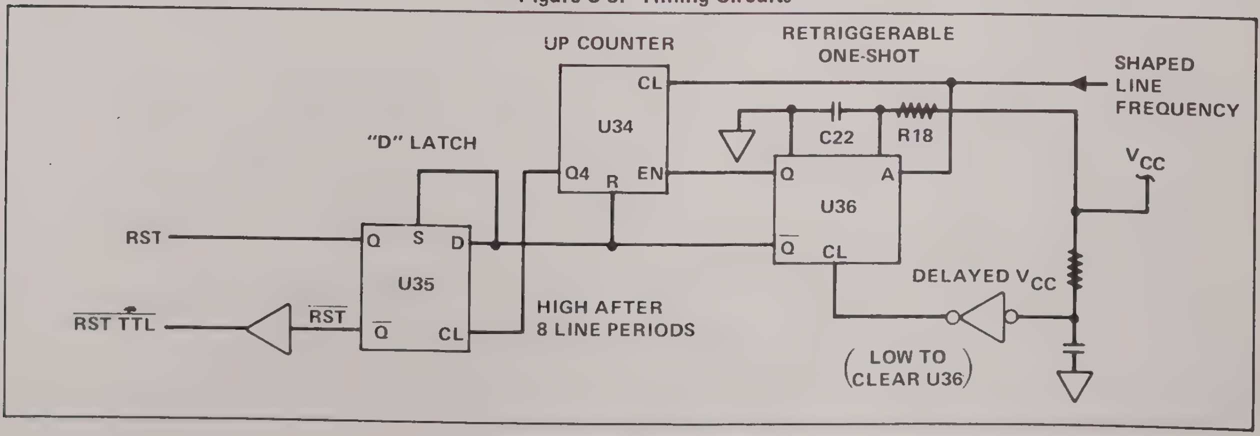

UP COUNTER
RETRIGGERABLE ONE-SHOT
CL
U34
SHAPED LINE FREQUENCY
C22
R18
"D" LATCH
Q4
R
EN
Q
A
V_{CC}
U36
RST
Q
S
D
$\overline{Q}$
CL
U35
DELAYED V_{CC}
RST TTL
$\overline{RST}$
$\overline{Q}$
CL
HIGH AFTER 8 LINE PERIODS
(LOW TO CLEAR U36)

Figure 3-10. Reset Logic

remove the wait state limiting the wait time to a single machine state.

3-47. ACK LOGIC

3-48. When a module is addressed by the Controller, or enabled for interrupt identification by INA from the Controller, it must return an ACK (high) signal. Refer to Figure 3-13. Either INTA (for interrupts) or A15 (for external addresses) together with the delayed ACK signal produce DLD ACK for U38, DLD ACK resets the ACK interrupt logic, which is timing the wait for ACK, and produces the ACK LAT signal through U15 and U27. RRDY must be low to get ACK LAT. This synchronizes ACK LAT to the SYNC TTL signal. ACK LAT (or ACK INT TTL if an ACK is missing) causes the microprocessor to exit the wait state.

3-49. INTERRUPTS

3-50. Two internal interrupts and four possible external interrupts are applied to the interrupt (INT) control logic (Figure 3-13). A low on OR gate U17 places a high on NAND gate U38. When INTE is high from the microprocessor (during the last state of an instruction cycle), U38 outputs a low through an RC delay network to U32. U32 inverts the signal and places a high on the INT line to interrupt the microprocessor. The microprocessor drops INTE low, then puts out an interrupt acknowledge (INTA) as a status word which is latched up in the Status Latch, U18. Then the microprocessor enters a wait state until the interrupt and its priority are identified through INT VECTOR, U28 (Controller schematic, Section 8).

3-51. Internal interrupts are ACK INT and MARK INT (Figure 3-14). ACK INT logic consists of a retriggerable

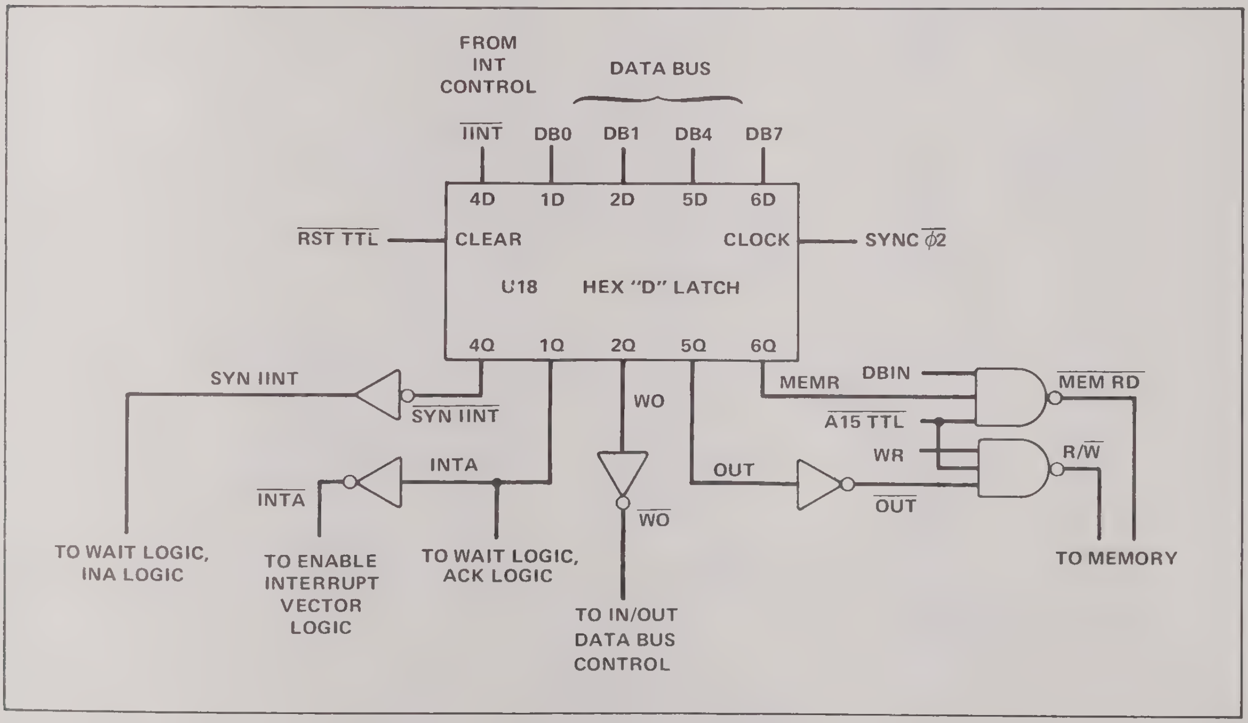

FROM INT CONTROL
DATA BUS
IINT
DB0
DB1
DB4
DB7
4D
1D
2D
5D
6D
RST TTL
CLEAR
CLOCK
SYNC φ2
U18
HEX "D" LATCH
4Q
1Q
2Q
5Q
6Q
SYN IINT
SYN IINT
WO
MEMR
DBIN
MEM RD
A15 TTL
WR
R/W
INTA
INTA
OUT
OUT
WO
TO WAIT LOGIC, INA LOGIC
TO ENABLE INTERRUPT VECTOR LOGIC
TO WAIT LOGIC, ACK LOGIC
TO IN/OUT DATA BUS CONTROL
TO MEMORY

Figure 3-11. Status Latch

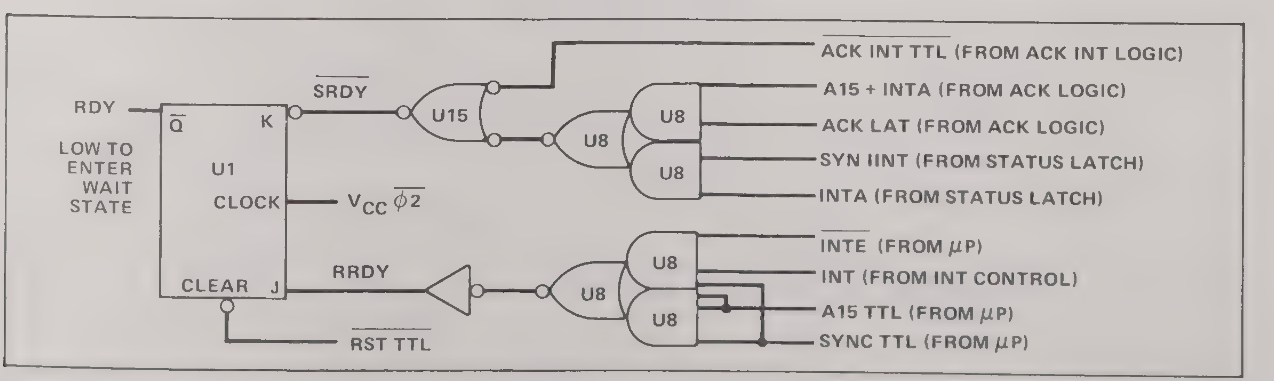

RDY
LOW TO ENTER WAIT STATE
Q
K
U1
CLOCK
CLEAR
J
SRDY
U15
VCC φ2
RRDY
RST TTL
U8
U8
U8
U8
U8
U8
ACK INT TTL (FROM ACK INT LOGIC)
A15 + INTA (FROM ACK LOGIC)
ACK LAT (FROM ACK LOGIC)
SYN IINT (FROM STATUS LATCH)
INTA (FROM STATUS LATCH)
INTE (FROM μP)
INT (FROM INT CONTROL)
A15 TTL (FROM μP)
SYNC TTL (FROM μP)

Figure 3-12. Wait Logic

monostable multivibrator, U36, and a "D" type flip-flop, U14. U36 is triggered by A15 TTL and SYNC $\overline{\phi 2}$. If DLD ACK does not occur within the time constant of U36, U36 will clock U14 to generate ACK INT. $\overline{\text{ACK INT TTL}}$ is also generated by U14 to end the wait state resulting from the external address.

3-52. The MARK INT logic is armed by an internal address keyed to RAM. A15 TTL is high indicating an internal address. DB4 is high as part of the status word indicating an address to an output device. $\overline{\text{A15 TTL}}$ and DB4 (both high) with SYNC $\overline{\phi 2}$ clock U1 through U31-12. $\overline{\text{A14}}$ is low for a RAM address so U1-7 is clocked high. Although the address which arms the mark is keyed to RAM, no data transfer takes place between the microprocessor and RAM. The write signal (R/$\overline{\text{W}}$) is disabled by OUT from the STATUS LATCH. $\overline{\text{MEM RD}}$ (memory read) is disabled by DBIN (from the microprocessor) and MEMR (from the STATUS LATCH) both being low. After ARM MARK (U1-7) is clocked high, the next pulse from the phase-locked loop timing circuit clocks U14 to generate the MARK INT signal.

3-53. Interrupts are prioritized through INT VECTOR (refer to Controller schematic, Section 8). Before entering a wait state after an interrupt, the microprocessor puts out a DBIN signal, signifying that it is ready to receive data. $\overline{\text{DBIN}}$ and $\overline{\text{INTA}}$ produce EN INT through U37 to enable the Interrupt Vector (U28). Internal interrupts are applied directly to U28 and have priorities of one (highest) for ACK INT and six (lowest) for MARK INT. For an internal interrupt, $\overline{\text{IINT}}$ is generated by one section of U38 (Figure 3-13) and, when latched into the Status Latch (U18), is used to end the wait state. For an external interrupt, SYN IINT is low and with $\overline{\text{EN INT}}$ low, INA is generated on the interbus. The interrupting module must respond with an

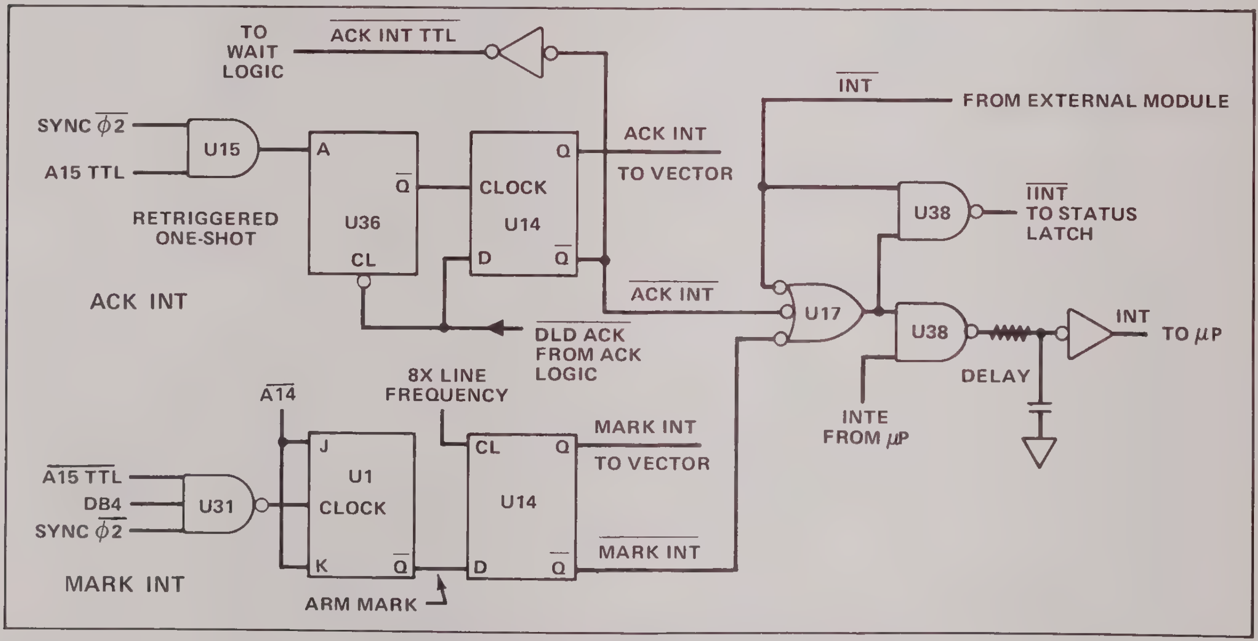

TO WAIT LOGIC
$\overline{\text{ACK INT TTL}}$
SYNC $\overline{\phi 2}$
A15 TTL
U15
A
Q̄
U36
CL
RETRIGGERED ONE-SHOT
CLOCK
U14
Q
D
Q̄
ACK INT
TO VECTOR
$\overline{\text{INT}}$
FROM EXTERNAL MODULE
U38
$\overline{\text{IINT}}$
TO STATUS LATCH
$\overline{\text{ACK INT}}$
U17
U38
INT
TO µP
DELAY
ACK INT
$\overline{\text{DLD ACK}}$
FROM ACK LOGIC
INTE FROM µP
8X LINE FREQUENCY
$\overline{\text{A14}}$
J
U1
CLOCK
K
Q̄
CL
Q
U14
D
Q̄
MARK INT
TO VECTOR
$\overline{\text{MARK INT}}$
$\overline{\text{A15 TTL}}$
DB4
SYNC $\overline{\phi 2}$
U31
MARK INT
ARM MARK

Figure 3-13. Internal Interrupts and INT Control

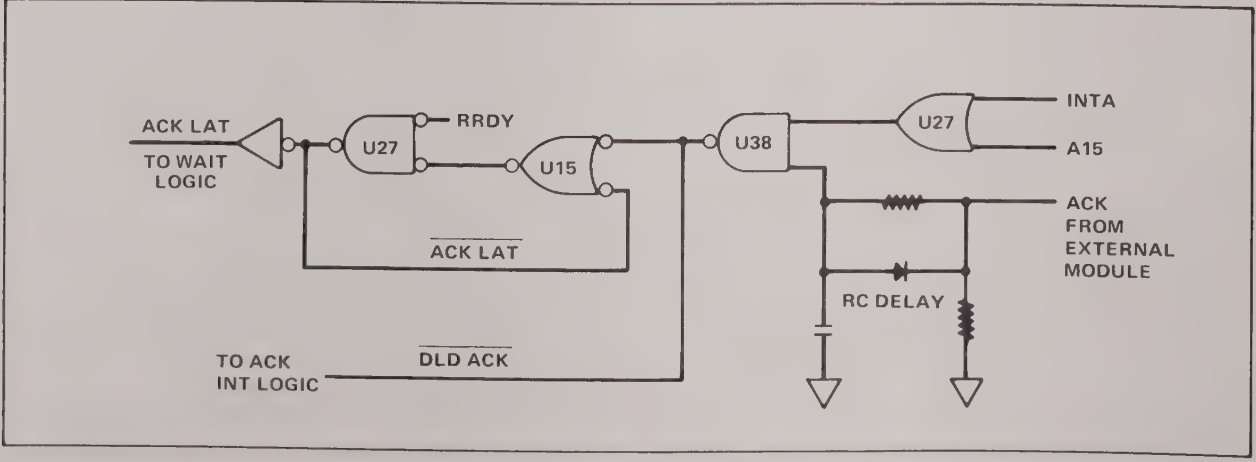

ACK LAT
TO WAIT LOGIC
U27
RRDY
U15
$\overline{\text{ACK LAT}}$
U38
U27
INTA
A15
ACK FROM EXTERNAL MODULE
RC DELAY
TO ACK INT LOGIC
$\overline{\text{DLD ACK}}$

Figure 3-14. ACK Logic

ACK and a data bit on ID1-4. The returned ACK ends the wait state and the data bit is applied to INT VECTOR, U28. The complement of the output from U28 is placed on the data bus to instruct the microprocessor where to go for the next instruction.

3-54. Front Panel

3-55. Annunciator segment data is clocked into register one by the direct address, IC0, 1, 5 high. Refer to Figure 3-15. Data output from the switch matrix is also a direct address–IC0, 1, 6 high. For either direct address, the condition of ID7 (high for disable) is latched into U23 to enable an indirect address. Digit segment address–IC1, 5 high, and digit-annunciator select address–IC0, 5 are both indirect addresses. Data is clocked into the registers upon termination of the address. An update sequence is as follows:

1. Register one is addressed with all data lines low to blank the annunciator display and enable indirect addressing.
2. Register two is addressed indirectly with data lines low to blank the digit display.
3. Register three is addressed indirectly with all data lines high to turn off all LEDs, disable the switch matrix, and disable indirect addressing.
4. Register one is addressed with ID7 low to enable indirect addressing and with annunciator segment data on ID0-6. The data is latched and applied to the annunciator LEDs.
5. Register two is addressed with digit segment data on ID0-7 (U23 is not clocked by this address so ID7 may be high without disabling indirect addressing). The data is latched and applied to the digit LEDs.
6. Register three is addressed with ID7 high (disable indirect addressing) and one of the data lines, ID0-6, low to enable one digit LED and one annunciator LED. One bank of the switch matrix is also enabled.
7. The output buffer is addressed enabling the data from the previously enabled switch bank to be placed on the data bus. One or more lines low indicates a change is desired. This address also keeps the kill circuit charged.

3-56. The seven steps just outlined are required for one digit-annunciator-switch bank update. The process is repeated seven times for a complete update. The kill circuit is used to blank the display if the Controller discontinues addressing the front panel. Otherwise, segments would be left on continuously and would soon burn out.

3-57. DC Signal Conditioner

3-58. Relays K1 and K2 control the input to the DC Signal Conditioner and the attenuation of the input (Figure 3-16). If both relays are energized, the input is from the Volt/Ω input terminals with ÷ 64 attenuation. If just K1 is energized, the input is from the Volt/Ω input terminals with no attenuation. If just K2 is energized, the input is from RT1 (optional signal conditioners). Q10, Q11, CR3, and CR4 provide overvoltage protection.

3-59. A differential amplifier (Q18, Q19) drives U3. FET switches (Q14, Q15, Q16) control the gain of Q18, and Q37. An output voltage swing of ±20V is achieved through bootstrapping; U4 provides a bootstrap for Q38 and Q37, and U5 and U6 provide a bootstrap for U3 and U4. Current sink and source for Q18 and Q19 are provided by Q38 and Q37 respectively.

3-60. The DC Signal Conditioner is addressed by IC0, 3, 4 high. Data on ID0-3 is latched up and decoded to determine which switches and relays will be energized. Figure 3-16 includes an example of the relay driver used to minimize thermal changes in the relays between the on and off states. RC coupling between the decoder and the relay driver provide voltage swings up to 4V or down to 0V to ensure positive relay action. Steady state voltages of 1.45V (off) and 2.75V (on) minimize current differences between the on and off states while maintaining the relay state under all conditions.

3-61. Filter/External Reference

3-62. All inputs to the A/D Converter are routed through the Filter/External Reference module. Refer to Figure 3-17. External reference measurements are made by multiplexing the three Filter module inputs to the A/D Converter. Q18, Q19, and Q20 switch the signal conditioner input, the external reference LO input, and the external reference HI input respectively. Data controlling the switches is latched into U1 upon termination of the address (IC1, 3, 4 high).

3-63. Three-pole, active Bessel filters (U3 and U4) have different settling times and cut-off points. Either filter may be selected from the front input panel for application to the signal conditioner input. Bypass is automatically selected for external reference inputs or may be remotely selected for signal conditioner inputs. The combination of Q32, Q25, Q23, Q24, or Q21, Q22 is turned on to select a filter mode.

3-64. A dual, super-beta transistor in a differential configuration (Q27) drives U5. A current source (Q26) and sink (Q30) bias Q27. Enough current is drawn through R19 by Q26 to bootstrap the input amplifier, Q27, 5V above the output. Gain of the amplifier is set at one by the combination of R21 and the input resistors. The external reference inputs have additional series resistors located at the rear panel terminals.

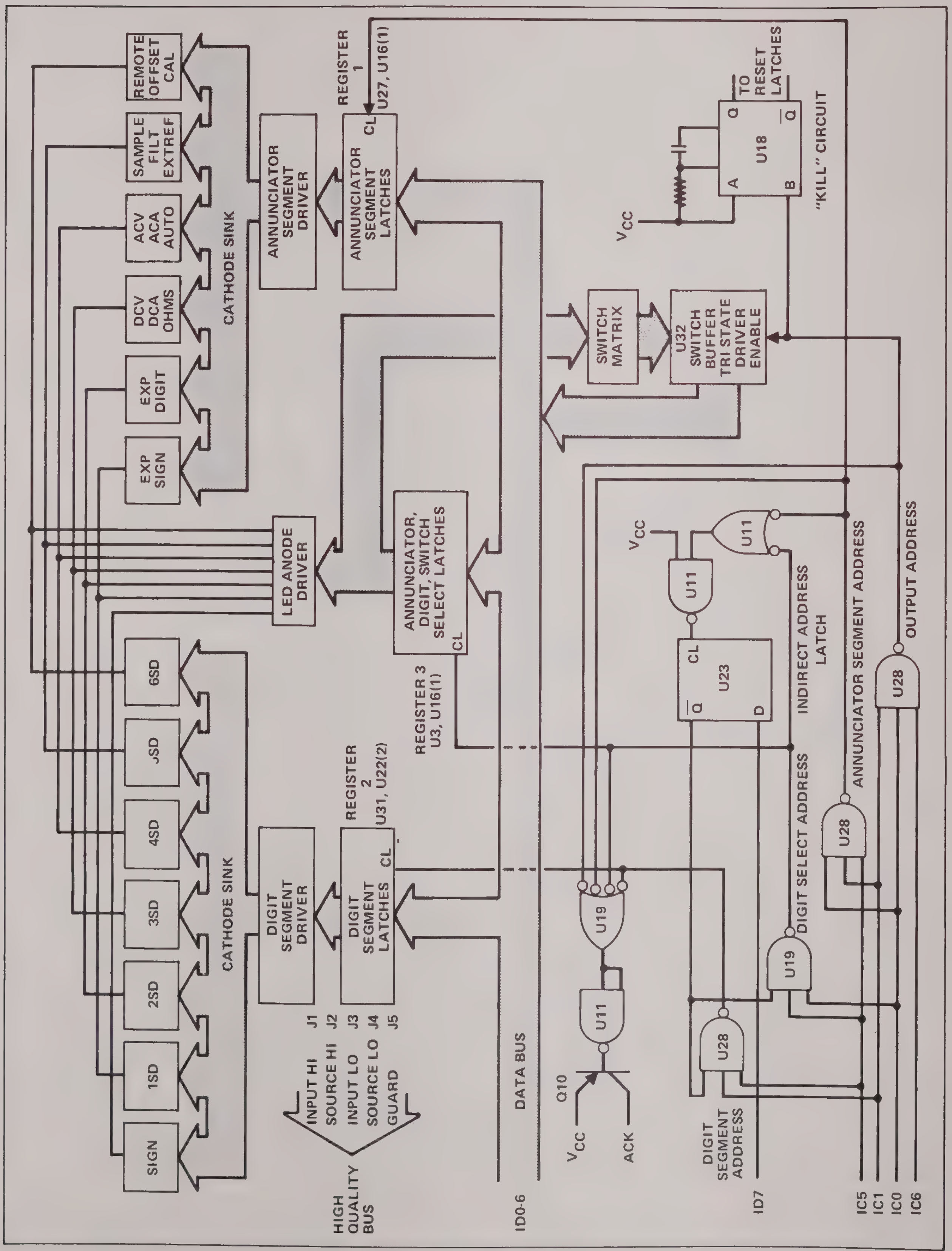

REMOTE OFFSET CAL
SAMPLE FILT EXTREF
ACV ACA AUTO
DCV DCA OHMS
EXP DIGIT
EXP SIGN
CATHODE SINK
ANNUNCIATOR SEGMENT DRIVER
ANNUNCIATOR SEGMENT LATCHES
CL
REGISTER 1
U27, U16(1)
TO RESET LATCHES
Q
$\overline{Q}$
U18
A
B
"KILL" CIRCUIT
V_{CC}
SWITCH MATRIX
U32 SWITCH BUFFER TRI STATE DRIVER ENABLE
LED ANODE DRIVER
ANNUNCIATOR, DIGIT, SWITCH SELECT LATCHES
CL
REGISTER 3
U3, U16(1)
V_{CC}
U11
U11
CL
U23
$\overline{Q}$
D
INDIRECT ADDRESS LATCH
ANNUNCIATOR SEGMENT ADDRESS
OUTPUT ADDRESS
U28
U28
DIGIT SELECT ADDRESS
U19
U28
DIGIT SEGMENT ADDRESS
ID7
IC5
IC1
IC0
IC6
6SD
5SD
4SD
3SD
2SD
1SD
SIGN
CATHODE SINK
DIGIT SEGMENT DRIVER
DIGIT SEGMENT LATCHES
CL
REGISTER 2
U31, U22(2)
U19
U11
Q10
V_{CC}
ACK
DATA BUS
ID0-6
HIGH QUALITY BUS
INPUT HI J1
SOURCE HI J2
INPUT LO J3
SOURCE LO J4
GUARD J5

Figure 3-15. Front Panel

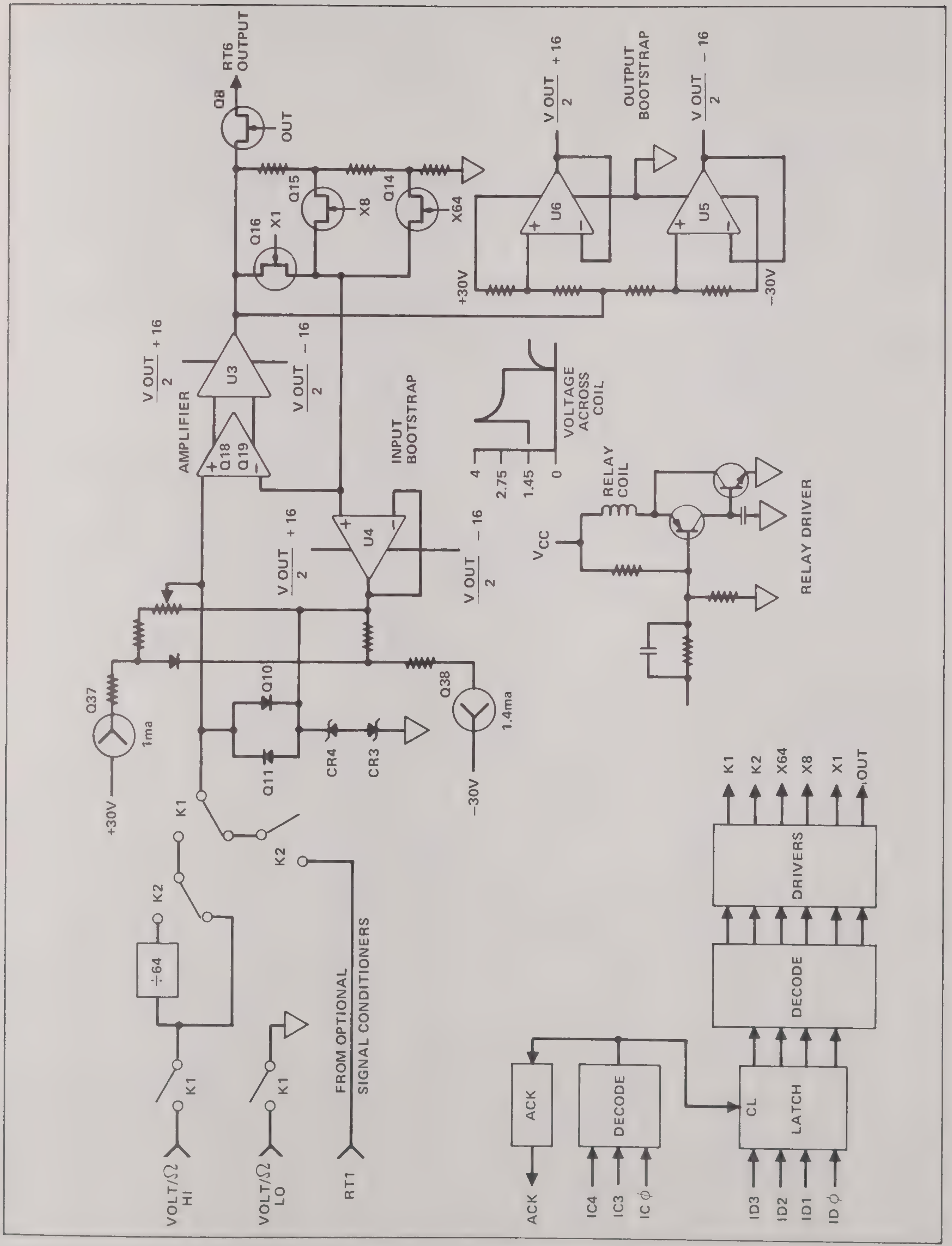

RT6
OUTPUT
Q8
OUT
Q15
X8
Q14
X64
Q16
X1
V OUT/2 + 16
OUTPUT BOOTSTRAP
V OUT/2 − 16
U6
U5
+30V
−30V
AMPLIFIER
V OUT/2 + 16
U3
V OUT/2 − 16
Q18
Q19
INPUT BOOTSTRAP
U4
V OUT/2 + 16
V OUT/2 − 16
4
2.75
1.45
0
VOLTAGE ACROSS COIL
RELAY COIL
V_CC
RELAY DRIVER
Q37
1ma
+30V
Q10
Q11
CR4
CR3
Q38
1.4ma
−30V
K1
K2
K2
÷64
K1
K1
VOLT/Ω HI
VOLT/Ω LO
FROM OPTIONAL SIGNAL CONDITIONERS
RT1
ACK
ACK
DECODE
IC4
IC3
IC ϕ
CL
LATCH
ID3
ID2
ID1
ID ϕ
DECODE
DRIVERS
K1
K2
X64
X8
X1
OUT

Figure 3-16. DC Signal Conditioner

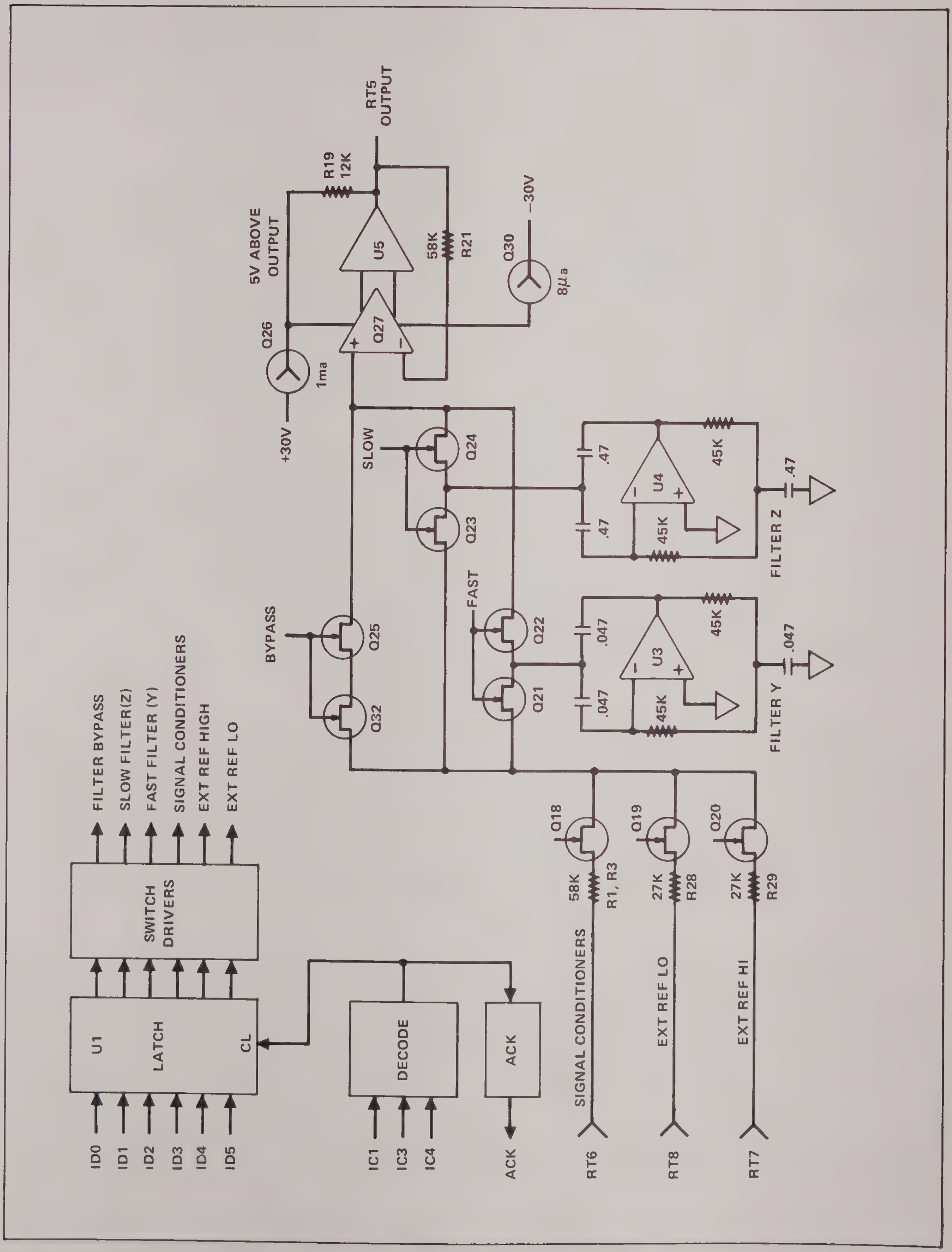

ID0
ID1
ID2
ID3
ID4
ID5
U1
LATCH
CL
SWITCH DRIVERS
FILTER BYPASS
SLOW FILTER(Z)
FAST FILTER (Y)
SIGNAL CONDITIONERS
EXT REF HIGH
EXT REF LO
IC1
IC3
IC4
DECODE
ACK
ACK
RT6
RT8
RT7
SIGNAL CONDITIONERS
EXT REF LO
EXT REF HI
58K
R1, R3
27K
R28
27K
R29
Q18
Q19
Q20
BYPASS
Q32
Q25
FAST
Q21
Q22
SLOW
Q23
Q24
.047
.047
U3
45K
45K
.047
FILTER Y
.47
.47
U4
45K
45K
.47
FILTER Z
+30V
Q26
1ma
Q27
5V ABOVE OUTPUT
U5
R19
12K
58K
R21
RT5 OUTPUT
Q30
8μa
-30V

Figure 3-17. Filter/External Reference

3-65. Fast R^2 A/D Converter

3-66. The Fast R^2 A/D Converter may be separated for analysis into two component groups: Analog and Digital. Analog circuitry is responsible for producing a voltage reference, for summations, and for remainder amplification and storage. Digital circuitry interfaces the analog circuitry to the Controller and is responsible for reference selection, decisions in the summation process, remainder channel control, and autozeroing. Since functions within the A/D Converter are either directly controlled by the Controller module via the data bus or are clocked through their operations by the Controller addressing the A/D module, the A/D conversion program could be considered a functional part of the A/D Converter.

3-67. ANALOG

3-68. Figure 3-18 isa simplified schematic of the analog portion of the A/D Converter. For clarity, switches are shown as a circle enclosing a letter designator. U1 is a reference and reference amplifier controlling U2, a current source. The -7V reference is set by R9 and R14. U3 serves as a highly regulated collector and zener supply for U1. Operation of the A/D Converter requires both a positive and negative reference (for negative and positive inputs, respectively). Q9 and U4 are a precision unity gain amplifier whose input is controlled by switches A1 and A2. With A1 open and A2 closed, Q9 and U4 are configured as an inverting amplifier producing a positive reference. With A1 closed and A2 open, Q9 and U4 are a noninverting amplifier.

3-69. An input signal is applied to the summing node of the remainder amplifier (Q27, U7) through switch I. Q27 and U7 are an inverting amplifier with two gain configurations. During the decision period, switch G is closed, applying the output of U7 to polarity detector Q28 and forming a feedback path through CR5 and CR6. Q28 sends a polarity bit to the digital portion of the circuitry. On the basis of this first polarity bit, a reference polarity is selected.

3-70. Switches B, C, D, E, and F are closed, one at a time, to switch a precise amount of current into the summing node. When a switch is closed, the opposite switch is opened and vice versa. For example, when D is closed, D is opened. After a switch is closed, a polarity bit is returned. If the polarity changed with respect to the original polarity selected for a step, the switch is opened; otherwise it is left closed. The next switch is closed, a polarity bit returned and a decision made, and so on until all five switches have been closed (and possibly opened again). This constitutes a decision period.

3-71. Following the decision period is the subtraction period. Switch G is opened and switches X and SX are closed to form a feedback path for the remainder amplifier through the X channel. A 400K resistor, R35, sets the gain of Q27 and U7 at sixteen. The feedback current completes the summation process and the amplified remainder is stored on C10 in the X channel.

3-72. For the next decision period switches SX and X are opened and switches RX and G are closed. Since Q27 and U7 form an inverting amplifier, the opposite polarity reference from the original selection) is automatically selected. The amplified remainder is applied to the summing node through U6 and R34. Five decisions are made, followed by a subtraction period using channel Y for feedback and remainder storage. The first decision-subtraction period applies the input signal to the summing node. The four following steps apply an amplified remainder, alternating between channel X and channel Y.

3-73. When a sample is complete, the circuits are autozeroed. U8 zeros the remainder amplifier through channel X. Any offset is stored on C13 at the noninverting input of Q27. The switching reference, Q9 and U4, is zeroed by first closing A1 and opening A2 to decrease settling time. Then A1 and A2 are both opened and the Z1 and Z2 switches are closed, storing any offset error on C5.

3-74. DIGITAL

3-75. For the following discussion, refer to the Digital Fast R^2 A/D schematic in Section 8. Direct address IC2, 3, 4 latches data into U34 and U35 controlling input switch I, remainder channel switches, autozero, and reset (digital). U31, a ring counter, is clocked to the C1 state enabling the indirect address decoder (U33) and the polarity detector (switch G). A polarity bit is returned and applied to U6.

3-76. Indirect address IC1, 2 latches the polarity bit in U6, enables the tristate transmitter, U5, and clocks U31 to the C2 state. The transition of U31 from C1 to C2 clocks the polarity into U11 (the uppermost section) whose output determines whether switch A1 or A2 will be closed (reference polarity). At the same time, U1 (uppermost section) is clocked to set the other section of U11, closing the first reference switch, B, of the A/D Converter. The next indirect address clocks a new polarity bit (a result of closing the first reference switch B) into U6. If the polarity changed, the output of U6 will cause a reset of the previous switch latch, opening the previous switch. At termination of the address the next switch is closed. One direct address and six indirect addresses are required to complete a step. The last indirect address resets the control logic to the C0 state.

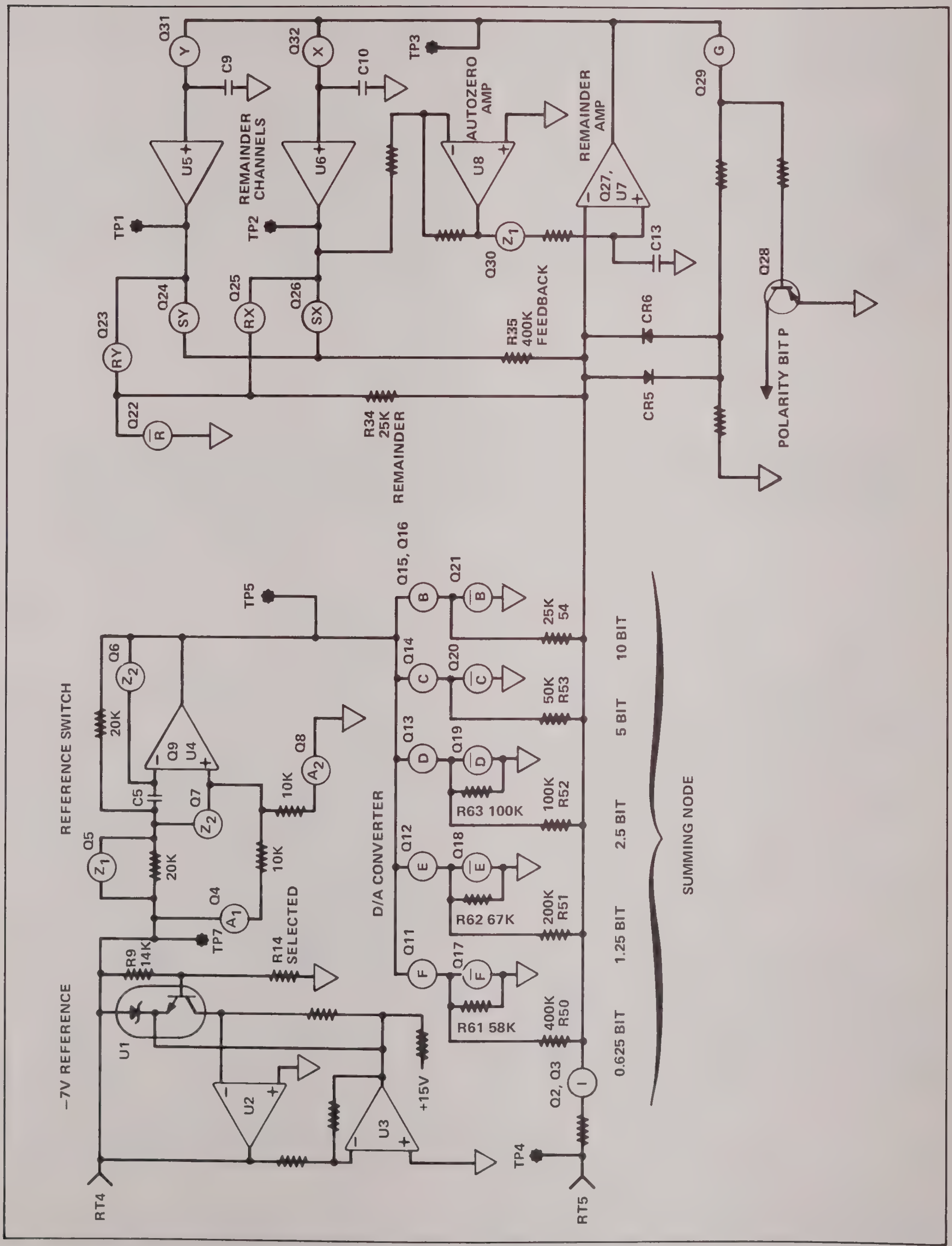

-7V REFERENCE
RT4
U1
U2
U3
+15V
R9 14K
R14 SELECTED
TP7
REFERENCE SWITCH
Q5
Z1
20K
Q4
A1
10K
C5
Q7
Z2
Q9 U4
20K
Q6
Z2
10K
Q8
A2
TP5
D/A CONVERTER
Q11
F
Q17
F
R61 58K
Q12
E
Q18
E
R62 67K
Q13
D
Q19
D
R63 100K
Q14
C
Q20
C
Q15, Q16
B
Q21
B
400K R50
200K R51
100K R52
50K R53
25K 54
0.625 BIT
1.25 BIT
2.5 BIT
5 BIT
10 BIT
SUMMING NODE
Q2, Q3
I
TP4
RT5
Q22
R
Q23
RY
Q24
SY
Q25
RX
Q26
SX
R34 25K REMAINDER
R35 400K FEEDBACK
TP1
TP2
U5
U6
REMAINDER CHANNELS
C9
C10
Q31
Y
Q32
X
TP3
U8
AUTOZERO AMP
Q30
Z1
Q27, U7
REMAINDER AMP
C13
CR5
CR6
Q29
G
Q28
POLARITY BIT P

Figure 3-18. Fast R^2 A/D Converter (Analog)

3-77. Switch selections are made through switch drivers which rely on Vcc and Vss being at –15V and –20V with respect to analog common. This allows simple transition from TTL levels to FET off voltages. D/A Converter switches are selected on transition of U31 from one state to the next. The transition clocks the first of two "D" flip-flops which sets the second. The output of the second latch resets the first and selects the switch. If the polarity does not change after closing a switch, the output of U6 plus the output of U11 (reference select) will place two highs on the input of one section of AND gate U25. Through OR gate, U16, a one will be applied to the D input of that switch latch. The next transition of U31 will clock the latch, keeping the switch closed. If the polarity had changed, a zero would be applied to the D input, opening the switch.

3-78. After the last step, at completion of a sample, the Controller addresses the A/D Converter for autozero. U31 is clocked to the C7 state causing a digital reset. When U6, storage capacitor disable, is reset, autozero is enabled. RC coupled gates delay the zero switch controls so that switch A1 may be closed and A2 opened in the reference switching circuit. This provides a faster settling time for the reference switching amplifier. Both A1 and A2 are opened during the autozero time.

Section 4

Maintenance

WARNING!

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual contains performance tests, calibration procedures, and maintenance information including general maintenance and troubleshooting. Calibration intervals may be determined by the user according to the accuracy desired (specifications are listed in Section 2). One year is the recommended maximum calibration interval. Test equipment recommended for performance tests, calibration adjustments, and troubleshooting is listed in Table 4-1. If the recommended equipment is not available, equipment of equivalent specifications may be used.

4-3. SERVICE INFORMATION

4-4. Each instrument manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of 1 year upon delivery to the original purchaser. The warranty terms are located at the front of the manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various worldwide locations. A complete list of domestic service centers is located in Section 7 of the manual. Shipping information is given in Section 2. If requested, the customer will be provided an estimate before any work begins on instruments that are beyond the Warranty period.

4-6. GENERAL MAINTENANCE

4-7. Line Voltage Selection

4-8. Input line voltage is switch selectable between 115V ac and 230V ac (check Section 2 for line voltage and frequency limitations). Removal of the top cover of the instrument allows access to the switch, located in the left front corner on the power supply board. Turn off the power and disconnect the line cord before removing the cover.

4-9. Fuse Replacement

4-10. The line fuse (MDL .5A) is found near the heat sink, on the rear panel. On the front panel, the front input current/ohms protection fuse (AGC 1.5A) is located in the lower right corner.

4-22. Motherboard PCB Removal

4-23. Remove the Motherboard PCB from the 8502A using the following procedure:

1. Remove the modules, the front panel pcb, and power supply interconnect pcb from the instrument if not already done.
2. Remove the eight screws that secure the motherboard to the bottom framework and lift the motherboard out through the front framework of the instrument.
3. Reassemble in the reverse order.

4-24. Cleaning Instructions

4-25. Periodically (at least every 90 days) clean the 8502A using the following procedure:

1. Ensure that the power is removed from the 8502A.
2. Remove the top and bottom covers from the instrument.
3. Disconnect the modules from the motherboard and remove them from the instrument.
4. Clean the interior of the 8502A using low pressure clean, dry air or a vacuum cleaner.
5. Clean the front panel and exterior surfaces with anhydrous ethyl alcohol or a soft cloth dampened with a mild solution of detergent and water.
6. Replace the modules and covers if access to the instrument interior is no longer required.

4-26. PERFORMANCE TEST

4-27. Introduction

4-28. The following paragraphs contain a performance verification test which compares the operation of the instrument to the specifications in Section 1 of this manual. The test may be used to verify calibration of the equipment between scheduled calibration periods or as an aid in troubleshooting.

4-29. The test equipment required for the Performance Test is listed in Table 4-1. If the recommended equipment is not available, replacements with equivalent specification may be substituted.

4-30. If the instrument does not meet the specifications listed in the Performance Test, either the calibration procedure or corrective maintenance should be performed, as determined by the symptoms. The test should be performed when the ambient temperature is between 18° and 28° Celsius and the relative humidity less than 75% to attain maximum accuracy.

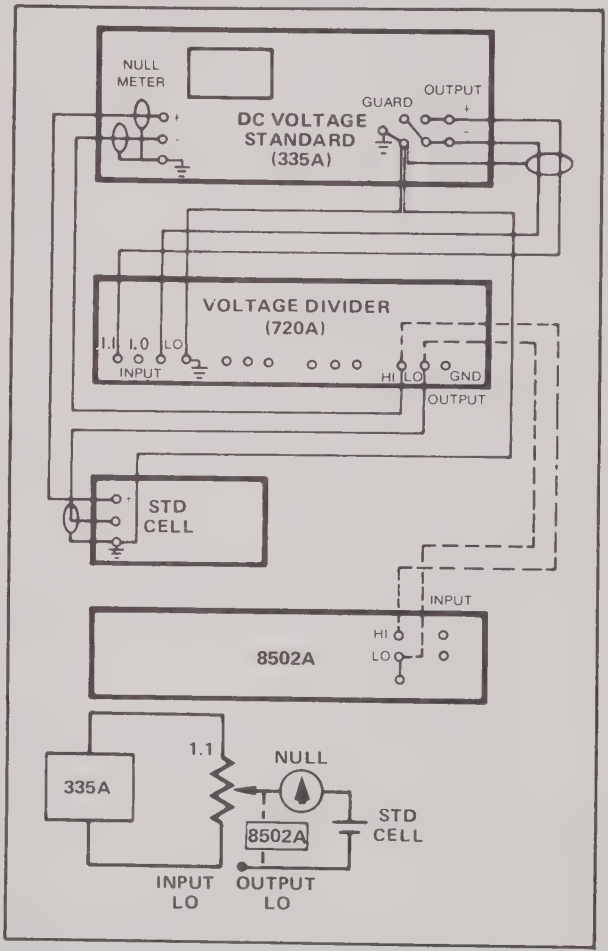


Figure 4-1. Connections For Low Range DC Voltage Tests

4-31. DC Performance Test

4-32. LOW RANGE DC VOLTAGE TESTS

4-33. Perform the Low Range Tests as follows:

1. Connect the equipment shown with solid lines in Figure 4-1. Do not connect the 8502A at this time.
2. Verify that the test equipment is operating properly and their respective warmup periods, as stated in the applicable manuals, have expired.

3. Verify that the 8502A warm-up period of two hours has elapsed. Ensure that the VDC and AUTO indicators are illuminated, the SAMPLE indicator flashes approximately eight times per second (32 samples per reading), and all other indicators are extinguished.

4. Set the Voltage Divider controls for one-tenth the standard cell certified value. Adjust the DC Voltage Standard output for a null on the null meter.

5. Disconnect the leads at the Voltage Divider output terminals and connect the 8502A as shown with the broken lines in Figure 4-1.

6. Perform the test listed in Table 4-2, setting the Voltage Divider to the listed outputs. Do not change the output setting of the DC Voltage Standard. After voltage has been applied to the 8502A but prior to the first reading, toggle the instrument into manual ranging.

7. Reverse the leads at the 335A output terminals (lead previously connected to the HI terminal now connected to the LO terminal and vice versa) and repeat the test listed in Table 4-2, ensuring that the listed outputs are now negative.

Table 4-2. Low Range DC Voltage Tests

RANGE	DIVIDER SETTING	8502A READING	
		LOW	HIGH
100 mV	.0010000	+ 9.995 (1−3)	+ 10.005 (−3)
100 mV	.0100000	+99.992 (−3)	+100.008 (−3)
1 V	.0100000	+ 0.09999	+ 0.10001
1 V	.1000000	+ 0.99997	+ 1.00003
10 V	.1000000	+ 0.9999	+ 1.0001
10 V	1.0000000	+ 9.9998	+ 10.0002

4-34. HIGH RANGE DC VOLTAGE TESTS

4-35. Perform the High Range Test as follows:

1. Connect the equipment as shown in Figure 4-2.

2. Verify that the test equipment is operating properly and any warmup period required has expired.

3. Verify that the 8502A warm-up period of two hours is complete. Ensure that the VDC function is selected with the VDC indicator illuminated and that the instrument is in manual ranging in the 100 volt range. The SAMPLE indicator should be flashing approximately eight times per second (32 samples per reading) and all other indicators should be extinguished.

4. Set the Reference Divider Standard Cell voltage controls to the standard cell certified value and both the input and output controls to 10 volts.

5. Set the DC Voltage Standard to approximately 10 volts, then adjust its output for a null reading on the null meter.

6. The 8502A reading displayed is between +9.999 and +10.001.

7. Set the Reference Divider input and output controls to 100 volts.

8. Set the DC Voltage Standard to approximately 100 volts, then adjust its output for a null reading on the null meter.

9. The 8502A reading displayed is between +99.997 and +100.003.

10. Increment the 8502A range manually to 1000 volts.

11. The 8502A reading displayed is between +99.99 and +100.01.

12. Set the Reference Divider input and output controls to 1000 volts.

13. Set the DC Voltage Standard to approximately 1000 volts, then adjust its output for a null reading on the null meter.

14. The 8502A reading displayed is between +999.97 and +1000.03.

15. Set the DC Voltage Standard to standby.

16. Reverse the leads at the DC Voltage Standard and standard cell terminals (lead previously HI to LO and vice versa).

17. Set the DC Voltage Standard to operate and repeat steps 4 through 15, ensuring that the listed outputs are now negative.

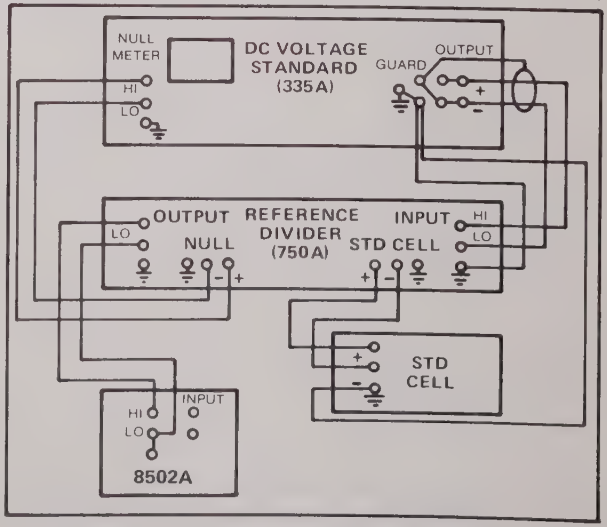


Figure 4-2. Connections For High Range DC Voltage Tests

4-36. AUTORANGING TEST

4-37. Test the autoranging capability of the 8502A with the following procedure:

1. Verify that the DC Volts and Autoranging modes are selected on the 8502A.
2. Connect the 8502A input directly to the DC Voltage Standard output.
3. Vary the output of the voltage source through its range, checking that the instrument autoranges approximately at the points indicated in Table 4-3.

Table 4-3. Autoranging

8502A CHANGES RANGE		NOMINAL READING
FROM	TO	
100 mV	1 V	312.5 mV
1 V	10 V	2.5 V
10 V	100 V	20 V
100 V	1000 V	160 V
1000 V	100 V	120 V
100 V	10 V	15
10 V	1 V	1.875
1 V	100 mV	0.234375

4-38. DC EXTERNAL REFERENCE

4-39. Test the DC four-wire true ratio, using the following procedure:

1. Connect the test equipment to the 8502A as shown in Figure 4-3.
2. Select the VDC function and Autoranging on the 8502A.
3. Set the DC Voltage Standard controls for +10.0000 volt output and the Voltage Divider controls to 1.000000.
4. Depress and hold the EXT REF switch. As long as the switch is held, the 8502A display reads the External Reference input of 10 volts (between 9.9998 and 10.0002).
5. Release the EXT REF switch. The 8502A computes the ratio (V_{IN}/V_{REF}) and displays a reading between 0.99996 and 1.00004.
6. Set the Voltage Divider controls to 0.1000000.
7. The 8502A displays a reading between 99.995 (-3) and 100.005 (-3).
8. Depress the EXT REF switch to toggle the 8502A out of the External Reference mode.
9. Remove power from the test equipment and disconnect it from the 8502A.

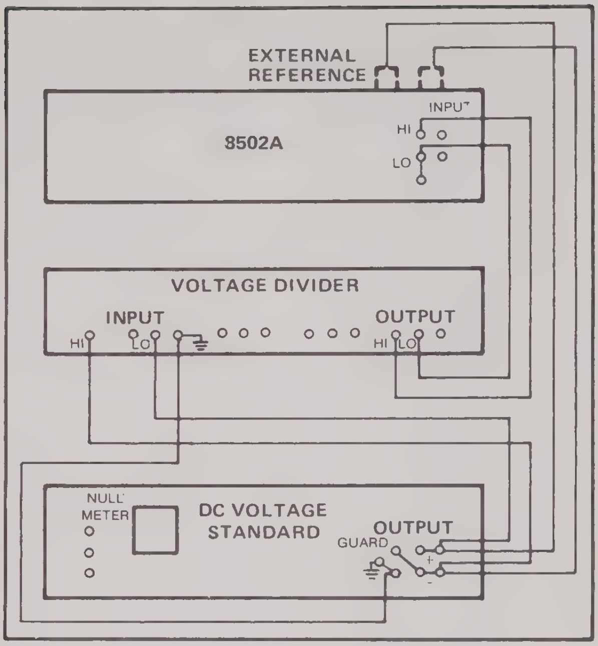


Figure 4-3. DC External Reference Test

4-40. CALIBRATION ADJUSTMENTS

NOTE

The standards called out in the following procedure are required to meet the published accuracy specifications. If published accuracy is not required for a particular function (e.g., Resistance, DC Current, etc), standards with a lower rated accuracy may be used.

4-41. Introduction

4-42. The 8502A should be calibrated every 90 days or 1 year, as required to meet the applicable accuracy specifications. It should also be recalibrated any time that repairs are made to the instrument. When performing the calibration, the ambient temperature should be 23°C ± 2°C and the relative humidity should be less than 75%. Refer to Table 4-1 for the recommended test equipment. Check the instruction manuals for the various pieces of test equipment for the correct warm-up periods. Power Supply adjustments are shown in Figure 4-4. Adjustments and test points on the remaining pcbs are accessible on the top edge of the board by popping open the hinged module top. Adjustments are labeled on the underside of the module top.

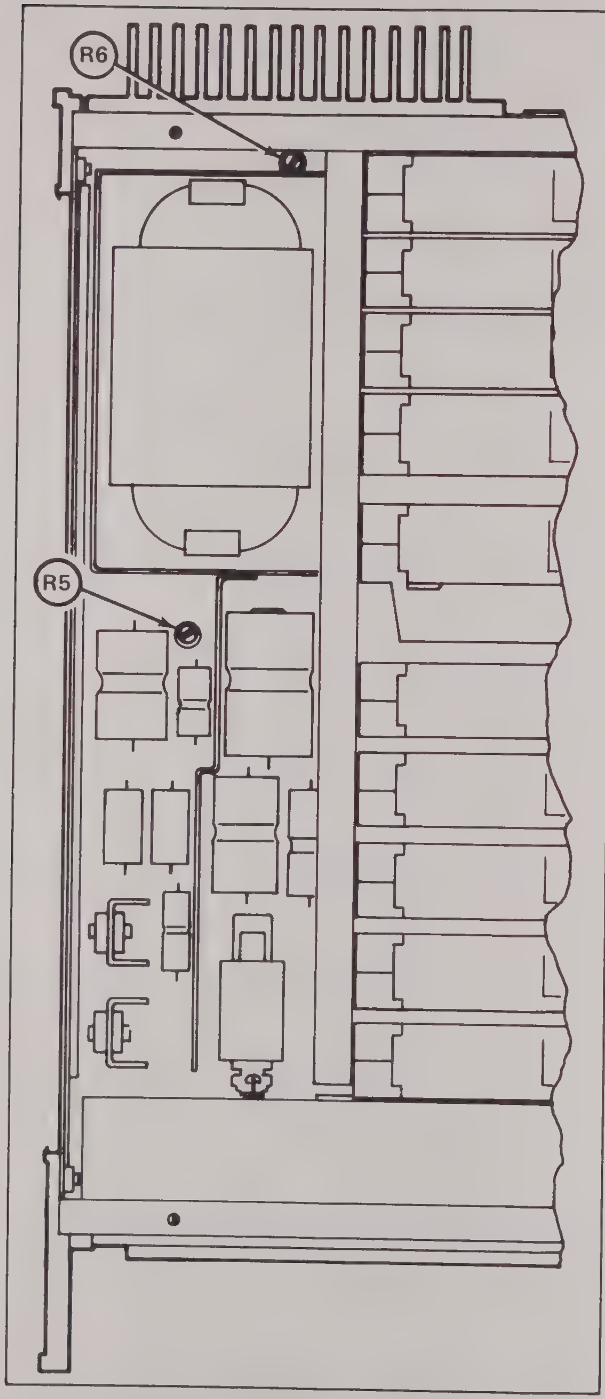


Figure 4-4. Power Supply Adjustments

4-43. Initial Procedure

4-44. With the POWER switch OFF, replace the Isolator or Bus Interconnect, whichever is installed, with the Bus Interconnect and Monitor Board, MIS-7013K. Remove the CAL Memory if installed. After completing calibration, reinstall the CAL Memory and enter new calibration factors (should be zeros). Set the POWER switch to ON and allow the instrument to warm-up for at least 1 hour before continuing with the calibration.

4-45. Power Supply

4-46. Perform the Power Supply checks and adjustments as follows:

CAUTION!

Do not use the 8502A to check its own supplies.

1. Connect the test DMM HI input to Vcc on the Bus Interconnect and Monitor Board and the LO input to Vss.
2. Adjust R6 for a reading between +5.00 and +5.10V dc to set the Logic Supply.
3. Transfer the HI DMM input lead to VA2.
4. Adjust R5 for a reading between +5.00 and +5.10V dc to set the Analog Supply.
5. Verify that the voltages in Table 4-4 are within the prescribed limits.
6. Prepare the test DMM to read AC volts and verify that the voltage between LINE and Vss reads between 13 and 17V ac.
7. Turn the POWER switch to OFF, remove the Bus Interconnect and Monitor Board, and return the Isolator or Bus Interconnect to the Instrument.
8. Reapply power to the 8502A.

Table 4-4. Power Supply Verifications

TEST POINTS		VOLTAGE RANGE (Vdc)		SUPPLY
HIGH	LOW	FROM	TO	
V_{DD}	V_{SS}	+ 11.4	+ 12.6	Logic
V_{GG}	V_{SS}	– 11.4	– 12.6	Logic
VA1	AR	+ 14.25	+ 15.75	Analog
VA2	AR	– 14.25	– 15.75	Analog
VA3	AR	+ 29.7	+ 31.7	Analog
VA4	AR	– 29.7	– 31.7	Analog

4-47. DC Calibration Procedure

4-48. There are two methods of performing dc calibration in the 8502A. If the Calibration Memory (Option –04) is installed, separate factors for each range and function may be entered from the front panel. This procedure is fully explained in Section 6. Alternately, dc calibration can be performed in the 100 mV range through the following adjustments on the DC Signal Conditioner module. If this procedure is followed, either the Calibration Memory module must be physically removed or the stored memory factors must be removed. To remove these factors:

1. Place the CAL switch down (CAL LED on).
2. Apply a good quality short across the input terminals (INPUT SENSE HI to LO).
3. Press STORE for each range (manually select ranges with UP and DN switches).

4-49. The offset adjustment, R14, in the Active Filter does not require adjustment unless Q27 or U5 have been replaced. There are no other adjustments in the Active Filter. Refer to troubleshooting, Figure 4-9, in this section for adjustment procedures for R14.

4-50. DC CONDITIONER ADJUSTMENTS

4-51. All adjustments and test points in the following procedures are on the DC Signal Conditioner. Perform the subtest, using the following procedure:

1. Select V DC, the 100 mV range, the slow filter (indicator on), samples per reading rate 7, and the CAL switch ON (CAL LED flashes).
2. Short the 8502A front input terminals.
3. Adjust R53 for a reading of exactly 0 μV.
4. Remove the short from the input terminals and apply a 1 MΩ/0.22 μF parallel load.
5. Adjust R52 for a reading between -0.002 and +0.002V dc (0 ±2 μV).
6. Repeat steps 2 through 5 until both readings are present without an adjustment.

4-52. A/D CONVERTER CALIBRATION PROCEDURES

4-53. Use the following procedures to calibrate the A/D Converter. All test points and adjustments are on the A/D Converter.

4-54. This paragraph contains the adjustment procedure for R64. R64 requires adjustment only if R54 in the tens bit ladder has been replaced during repair. Unless R54 has been replaced, go on to the next paragraph.

1. Connect the test DMM HI to TP7, LO to TP6.
2. Adjust R1 for a test DMM reading of -7.000X V.
3. Remove the test DMM.
4. Using the test connections in Figure 4-1, apply 10.10000 volts dc to the 8502A input terminals.
5. Adjust R64 for an 8502A reading of +10.10000 ±5 cal digits.
6. Continue with the following adjustments.

4-55. A/D Zero Adjustment

4-56. Using the following steps to adjust auto zero in the A/D Converter:

1. Select the 10V range on the 8502A.
2. Short the 8502A input terminals.
3. Adjust R8 for a reading of 0.0000-0 ±1 cal digit.

4-57. A/D Calibrator Settings

4-58. Prepare the DC Voltage Standard for use during the A/D Calibration using the following procedure:

1. Connect the equipment, as shown with the solid lines in Figure 4-1. Do not connect the 8502A at this time.
2. Set the Voltage Divider controls at one-tenth the standard cell certified value (standard cell value x 0.1).
3. Adjust the DC Voltage Standard output for a null on the null meter.
4. Record the dial setting of the DC Voltage Standard as "Control Setting A." This setting will be used later in the procedure, in addition to the following paragraph.
5. Disconnect the leads at the Voltage Divider output terminals from the null meter and standard cell and connect the 8502A as shown with the broken lines in Figure 4-1.

4-59. A/D Ladder Adjustments

4-60. Use the following steps when adjusting the A/D Ladder:

1. Select the 10V manual range on the 8502A.
2. Set the Voltage Divider controls for a ratio of 1.0100000.
3. Adjust R1 for a reading between +10.0999-9 and +10.1000-1 (+10.1000-0 ±1 cal digit).

4. Reverse the polarity of the dc voltage at the DC Voltage Standard for a negative input to the 8502A.

5. Adjust R2 for a reading between -10.0999-9 and -10.1000-1 (-10.1000-0 ±1 cal digit). If these adjustments cannot be made, perform A/D Converter Calibration Procedures.

6. Return the polarity of the dc voltage to a positive output from the DC Voltage Standard input at the 8502A.

7. Set the Voltage Divider controls for a ratio of .0500000.

8. Adjust R7 for a reading between +0.4999-9 and +0.5000-1 (+0.5000-0 ±1 cal digit).

9. Repeat steps 2 through 8 until all readings are within tolerance without making an adjustment.

10. Set the Voltage Divider controls for ratio of .5100000.

11. Adjust R6 for a reading between +5.0999-9 and +5.1000-1 (+5.1000-0 ±1 cal digit).

12. Set the Voltage Divider controls for a ratio of .2600000.

13. Adjust R5 for a reading between +2.5999-9 and +2.6000-1 (+2.6000-0 ±1 cal digit).

14. Set the Voltage Divider controls for a ratio of .1400000.

15. Adjust R4 for a reading between +1.3999-9 and +1.4000-1 (+1.4000-0 ±1 cal digit).

16. Set the Voltage Divider controls for a ratio of .0750000.

17. Adjust R3 for a reading between +0.7499-9 and 0.7500-1 (0.7500-0 ±1 cal digit).

18. Repeat steps 2 through 17 until all steps are within the stated tolerance.

4-61. Linearity Verification

4-62. Use the following procedure to check linearity for the 8502A:

1. Verify that the 8502A reading rate is set at 128 samples/reading and the 10V manual range is selected.

2. Set the Voltage Divider controls for a ratio of .2000000.

3. Set the DC Voltage Standard for an output of approximately 100 volts and adjust its output for a reading between +19.9999-9 and +20.0000-1 on the 8502A.

4. Set the Voltage Divider controls for a ratio of .0000000 and verify that the reading is between -0.0000-1 and +0000-1 (0 ±1 cal digit).

5. Reverse the polarity of the dc voltage at the DC Voltage Standard for negative input to the 8502A.

6. Verify that the 8502A reads between -0.0000-1 and +0.0000-1 (0 ±1 cal digit).

7. Return the polarity of the dc voltage output from the DC Voltage Standard to a positive input at the 8502A.

8. Set the Voltage Divider controls to the settings listed in Table 4-5, verifying that the readings are within the tolerances listed in the table.

9. Reverse the polarity of the DC Voltage Standard output and repeat the steps in Table 4-5, checking that the reading is negative and within the listed tolerance.

10. Set the DC Voltage Standard for the "Control Setting A" recorded earlier.

11. Set the Voltage Divider controls for a ratio of 1.0000000.

12. Verify that the 8502A reads between +9.9999-9 and +10.0000-1 (+10.0000-1 ±1 cal digit).

Table 4-5. Linearity Checks

DIVIDER SETTING	READINGS		
	MINIMUM	NOMINAL	MAXIMUM
.0100000	0.9999-5	1.0000-0	1.0000-5
.0200000	1.9999-5	2.0000-0	2.0000-5
.0300000	2.9999-5	3.0000-0	3.0000-5
.0400000	3.9999-5	4.0000-0	4.0000-5
.0500000	4.9999-5	5.0000-0	5.0000-5
.0600000	5.9999-5	6.0000-0	6.0000-5
.0700000	6.9999-5	7.0000-0	7.0000-5
.0800000	7.9999-5	8.0000-0	8.0000-5
.0900000	8.9999-5	9.0000-0	9.0000-5
.1000000	9.9999-5	10.0000-0	10.0000-5
.1100000	10.9999-4	11.0000-0	11.0000-6
.1200000	11.9999-4	12.0000-0	12.0000-6
.1300000	12.9999-4	13.0000-0	13.0000-6
.1400000	13.9999-3	14.0000-0	14.0000-7
.1500000	14.9999-3	15.0000-0	15.0000-7
.1600000	15.9999-3	16.0000-0	16.0000-7
.1700000	16.9999-2	17.0000-0	17.0000-8
.1800000	17.9999-2	18.0000-0	18.0000-8
.1900000	18.9999-2	19.0000-0	19.0000-8
.2000000	19.9999-2	20.0000-0	20.0000-8

4-63. RANGE ADJUSTMENTS

NOTE

If the Calibration Memory option is included with the unit, refer to Section 6 for reinstallation and setup.

4-64. All adjustments and test points in the following procedure are on the DC signal conditioner. Perform the subtests using the following procedures.

4-65. Use the following steps to adjust the 100mV range:

1. Ensure that the DC Voltage Standard is set for "Control Setting A."
2. Set the Voltage Divider controls for a ratio of .0000000.
3. Select the 100 mV range on the 8502A.
4. If required, readjust R53, for a reading of 0±0 μV.
5. Set the Voltage Divider controls for a ratio of .300000.
6. Adjust R49 for a reading between +299.999 and +300.001 (+300.000 ±1 digit).

4-66. Use the following procedure to adjust the 1V range:

1. Select the 1V range on the 8502A.
2. Set the Voltage Divider controls for a ratio of .2500000.
3. Adjust R48 for a reading between +2.49999-9 and +2.50000-1 (+2.50000-1 ±1 cal digit).

4-67. Use the following procedure to adjust the 100V range:

1. Connect the equipment as shown in Figure 4-2.
2. Select the 100V range on the 8502A.
3. Set the Reference Divider Standard Cell voltage controls to the standard cell certified value and both the input and output controls to 100 volts.
4. Set the DC Voltage Standard to approximately 100 volts, then adjust its output for a null on the null meter.
5. Adjust R47 for a reading between +99.999-9 and 100.000-1 (+100.000-0 ±1 cal digit).

4-68. Use the following procedure to adjust the 1000V range:

1. Select the 1000V range on the 8502A and take the instrument out of the Cal mode by moving the CAL switch to OFF (CAL indicator extinguishes).
2. Verify that the 100 volt setting on the Reference Divider is still nulled.
3. The 8502A should read between +99.98 and +100.02 (+100.00 ±2 digits).
4. Set the Reference Divider input and output controls to 500 volts.
5. Set the DC Voltage Standard to approximately 500 volts, then adjust its output for a null on the null meter.
6. The 8502A should read between +499.98 and +500.02 (+500.00 ±2 digits).
7. Set the Reference Divider input and output controls to 1000 volts.
8. Set the DC Voltage Standard to approximately 1000 volts, then adjust its output for a null on the null meter.
9. The 8502A should read between +999.98 and +1000.02 (1000.00 ±2 digits).

4-69. TROUBLESHOOTING

4-70. Static discharge can damage components contained in the 8502A. The following precautions should be observed during troubleshooting, repair, or module replacement.

1. Never connect or disconnect modules or components without first turning the 8502A's Power switch to OFF.
2. Perform all repairs at a static-free work station.
3. Minimize handling of IC's and pcb's; in no case handle them by their connectors.
4. Keep repair parts in their original containers until ready for use.
5. Use static ground straps to discharge repair personnel.

6. Use conductive foam or anti-static containers to store replacement or removed IC's and pcb's.

7. Remove all plastic, vinyl and styrafoam products from the work area.

8. Do not slide static sensitive devices over any surface.

9. Use only anti-static type solder removal tools.

10. Use grounded tip soldering irons.

4-71. A procedure for isolating faulty modules is contained in Table 4-6. It is important that the theory of operation given in Section 3 be read before attempting to troubleshoot the 8502A. The module isolation procedure involves making observations of the 8502A behavior, then removing or replacing modules to establish cause-effect relationships. DO NOT remove or replace modules with the power on. Follow the procedure step by step all the way through to assure that the fault is isolated to the correct module. Faults in some modules may cause apparent faults in other modules.

WARNING

IF THE ISOLATOR AND THE BIT SERIAL INTERFACE ARE INSTALLED, REPLACEMENT OF THE ISOLATOR BY THE BUS INTERCONNECT MONITOR BOARD MAY ALLOW A HAZARDOUS COMMON MODE VOLTAGE TO APPEAR ON THE OUTPUT CONNECTOR OF THE INTERFACE.

4-72. Figures 4-5 through 4-11 contain symptom analysis troubleshooting information for each of the modules and pcb's contained in the mainframe 8502A. The possible failures are listed in order of probability. Troubleshooting information for optional modules is contained in Section 6.

4-73. Troubleshooting Notes

4-74. Error codes are disabled in the CAL mode. Selection of a function for which the module is either faulty or missing will then result in random readings.

4-75. If interaction between modules is a problem during troubleshooting, use of either the Static Controller (MIS-7190K) or the Test Module (MIS-7191K) could be helpful. With the Static Controller, bus IC, ID, and handshake signals may be applied separately to most analog and digital modules. The Test Module may be used to either check or troubleshoot the Controller module. Complete use information and troubleshooting techniques are provided with these test modules.

4-76. Use the Bus Interconnect and Monitor Board (MIS-7013K) to access lines on either the digital (unguarded) or analog (guarded) interbus. In using the Bus Interconnect Monitor Board, note that RT1 physically does not extend to the Isolator-Interconnect slot. RT1 is accessible with the Monitor Board installed in any of the first four slots (J11A, B, C, or D). The output of the optional Ohms Converter and Current Shunts modules are on RT1.

CAUTION

Do not apply an input directly to the A/D Converter module. Damage to the A/D Converter may result. The DC Signal Conditioner may be bypassed by applying a signal directly to the Active Filter module, as outlined in the module isolation procedure.

4-77. Care should be exercised when soldering on multilayer printed circuit boards. Excessive heat can be especially ruinous. Note the following considerations:

1. Excessive heat can cause unseen damage to board laminations and through-hole plating.

2. Soldering tip temperatures above 700°F should, in all cases, be avoided.

3. Whenever possible, alternate soldering tool usage between divergent areas on a board. Concentration of heat in any one area will thereby be minimized.

4-78. Non-recurring Adjustments

4-79. POWER SUPPLY ASSEMBLY

4-80. Variable resistor R9 in the U3 Regulator circuit of the A4 Power Supply Assembly (Rev. E and subsequent) is set at the factory and should not require additional adjustment. If any components in the circuit are replaced during troubleshooting it can be adjusted or verified using the following procedure:

1. Connect a test DMM between -15V (VA2) and ANALOG RETURN (AR) on pins 5,14 and 7,16 of the Guarded Bus connector (P1) respectively.

2. Record the value of the reading.

3. Connect the test DMM between +15V (VA1) and AR on pins 6,15 and 7,16 of P1 respectively.

4. Adjust R9 until the test DMM reads within ±0.25V of the reading recorded in step 2 above.

5. Recheck the -15V and +15V supplies at the points given in steps 1 and 3 above respectively and verify that they read -15±0.75V and +15±0.75V. If either is outside the stated tolerance repeat steps 1 through 4 until both values are within tolerance.

Table 4-6. Faulty Module Isolation

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1.	Turn the power ON. The following should be displayed. HI–2.0.Y (Y=Program number) then C XXXXX (X = installed option number) then 0.00 ±.05 (DC Volts, 1000V range, Fast sample rate)		
2.	Is the display blank?	6	3
3.	Is the initial display other than HI–2.0.Y?	42	4
4.	Is the reading other than 0.00 ±.05	59	5
5.	Are the first three displays normal?	78	2
	DISPLAY BLANK AT POWER ON		
6.	Remove bus interconnect (or Isolator if installed).		
7.	Turn power ON. Is HI–2.0.Y displayed?	8	11
8.	Was the isolator installed?	9	11
9.	Install interconnect-monitor in the Isolator slot. Is HI–2.0.Y displayed?	10	13
10.	Bad Isolator. Go to Section 6 under Isolator.		
11.	Is the power indicator on?	17	12
12.	Check the fuse. Is it bad (replace)?	1	17
13.	Remove Cal Memory and remote interfaces if installed. Is HI–2.0.Y displayed?	14	17
14.	Replace Cal Memory. Is HI–2.0.Y displayed?	16	15
15.	Bad Cal Memory. Go to Section 6 under Calibration Memory.		
16.	Bad Remote Interface. Go to Section 6 under the appropriate interface.		
17.	Install the interconnect-monitor PCB in the Isolator slot.		
18.	Check power supply voltages as follows. Test DMM Common to VSS. V_{DD} = +11.4 to +12.6 V_{CC} = +5.15 to 5.25 V_{GG} = −11.4 to −12.6 LINE = 13V ac to 17V ac		
19.	Are the power supplies within tolerance?	26	20
20.	Remove all modules except the Front Panel.		
21.	Recheck power supplies. Within tolerance?	22	23
22.	Replace modules one at a time (start with Controller), rechecking supplies after replacing each module. The last one put in when the supplies go bad is the problem. Go to the appropriate figure for that module.		
23.	Remove the front panel. Recheck supplies. Within tolerance?	25	24
24.	Problem on power supply, motherboard, or power supply interconnect.		
25.	Bad Front Panel. Go to Figure 4-7.		

Table 4-6. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
26.	Remove Cal Memory and the remote interface if installed.		
27.	Check IC 6, 5, 1, 0 on interbus. All moving?	28	30
28.	Check ACK line. Moving?	29	30
29.	Check ID0 –7. All moving?	32	30
30.	Check Controller clock, TP2, TP3 (TP1 = gnd). Is 12V, 1.7 MHz signal present?	33	31
31.	Bad Controller. Go to Figure 4-6.		
32.	Bad Front Panel. Go to Figure 4-7.		
33.	Remove analog modules, leaving only Controller, Front Panel, and Interconnect. Is the display normal?	34	35
34.	Faulty Analog Module. Replace one at a time — last one in is the problem. Go to the appropriate figure for that module		
35.	Remove Front Panel, replace DC Signal Conditioner, Filter, A/D Converter.		
36.	Check IC lines, ACK line, ID lines. All moving?	38	37
37.	Bad Controller. Go to Figure 4-6.		
38.	Bad Front Panel. Go to Figure 4-7.		
	INITIAL DISPLAY OTHER THAN HI–2.0.Y		
39.	Remove Interconnect PCB (or Isolator if installed).		
40.	Apply power. Is the display as follows? HI–2.0.Y C XXXXX Error 9	41	44
41.	Was the Isolator installed?	42	47
42.	Install Interconnect-monitor PCB in Isolator slot. Is display normal?	43	48
43.	Bad Isolator. Go to Section 6.		
44.	Are Cal Memory or remote interface installed?	45	47
45.	Remove Cal Memory and remote. Display normal?	46	47
46.	Replace one at a time. Go to appropriate figure.		
47	Install Interconnect-Monitor PCB.		
48.	Check for shorts between the IC and the ID lines. Shorts?	49	51
49.	Remove all modules except Front Panel. Removed short?	50	57
50.	Reinstall modules one at a time (start with Controller), checking for shorts between modules. Last one in is the problem. Go to the figure for the appropriate module.		

Table 4-6. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
51.	Are any of the IC, ID, or ACK lines always high or always low?	53	52
52.	Remove all modules except Front Panel and Controller. IC and ID moving?	56	53
53.	Remove Front Panel. Reinstall dc analog modules if removed.		
54.	Are the IC, ID, and ACK lines moving?	57	55
55.	Bad Controller. Go to Figure 4-6.		
56.	Is the display normal?	58	57
57.	Front Panel bad. Go to Figure 4-7.		
58.	Faulty Analog module. Replace one at a time until symptoms recur. Last one in is faulty. Go to the figure for the appropriate module		
	READING NOT ZERO AT TURN ON		
59.	Remove all optional modules (except Isolator if installed), leaving Controller, (Isolator), DC Signal Conditioner, Filter, A/D, Front Panel.		
60.	Apply power. Is the reading zero?	61	62
61.	Replace modules one at a time until reading is not zero. Last one in is the problem. Go to Section 6.		
62.	Is the Isolator installed?	63	65
63.	Replace Isolator with Interconnect-Monitor PCB. Is the reading zero?	64	65
64.	Bad Isolator. Go to Section 6.		
65.	Install Interconnect Monitor if not already installed. Check supply voltages as follows. Test DMM LO on AR (analog return). VA1 = +14.25 to +15.75 V VA4 = −29 to −32 V VA2 = −14.25 to −15.75V V_{CC} = −15V } Difference must equal VA3 = +29 to +32V V_{SS} = −20V } 4.9 to 5.2V		
66.	Supply voltages in tolerance?	70	67
67.	Remove all modules except Front Panel. Supplies in tolerance?	69	68
68.	Repair power supply. Go to Figure 4-5.		
69.	Replace modules one at a time, checking supplies between modules. Last one in is faulty. Go to the appropriate figure.		
70.	Remove Filter module. CAL switch on. Select DC Volts, 1000V range.		
71.	Is the reading zero?	72	77
72.	Replace Filter module; remove DC Signal Conditioner.		
73.	Place a jumper (short) between RT2 and RT6.		
74.	Is the reading zero (disregarding CAL digit)?	75	76

Table 4-6. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
75.	DC Signal Conditioner bad. Go to Figure 4-8.		
76.	Filter module bad. Go to Figure 4-9.		
77.	A/D converter bad. Go to Figure 4-10.		
78.	Do the Performance Tests earlier in this section.		
79.	Is the unit within the tolerances given?		80
80.	Is the Cal Memory installed?	81	83
81.	Remove the Cal Memory. Is the unit now within tolerance?	82	83
82.	Faulty Cal Memory. Go to Section 6.		
83.	Is the Isolator installed?	84	87
84.	Replace Isolator with Interconnect-monitor PCB.		
85.	Is unit within tolerance?	86	87
86.	Bad Isolator. Go to Section 6.		
87.	Is the failure in DC Volts Performance Test?	89	88
88.	Go to Section 6 for the appropriate faulty function.		
89.	Remove all optional modules, leaving Front Panel, Controller, DC Signal Conditioner, Active Filter, and A/D Converter.		
90.	Do the DC Volts Performance Test. Is the unit within tolerance?	91	92
91.	Reinstall options one at a time, rechecking DC Volts tolerance. Last module installed when unit becomes out of tolerance is faulty. Go to Section 6.		
92.	Check supply voltages according to the following chart. VA1 = +14.25 to +15.75V VA4 = –29 to –32V VA2 = –14.25 to –15.75V V_{CC} = –15V) Difference = 4.9 to 5.2V VA3 = +29 to +32V V_{SS} = –20V)		
93.	Are the supplies within tolerance?	97	94
94.	Remove all modules except Controller and Front Panel. Are the voltages correct?	95	96
95.	Replace modules one at a time until the voltages go bad. Last one in is the problem. Go to the appropriate figure.		
96.	Repair power supply. Go to Figure 4-5.		

Table 4-6. Faulty Module Isolation (cont)

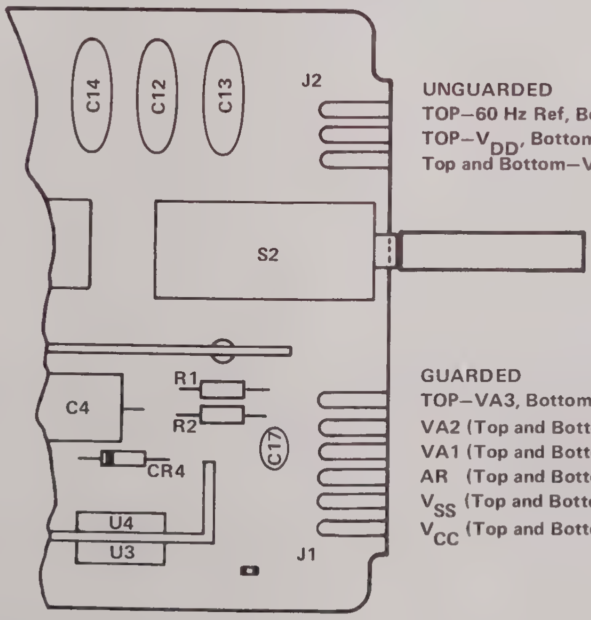
<table>
<tr><th rowspan="2">STEP NO.</th><th rowspan="2">ACTION</th><th colspan="2">Go to the step number given for correct response</th></tr>
<tr><th>YES</th><th>NO</th></tr>
<tr><td>97.</td><td>Connect the test DMM LO to RT2 and HI to RT6. Apply known voltages to the 8502A input to test the DC Signal Conditioner. The following voltages are suggested inputs:
<table>
<tr><th>8502A RANGE</th><th>GAIN DC SIG COND</th><th>INPUT</th><th>TEST DMM READING</th></tr>
<tr><td>100mV</td><td>X64</td><td>2mV</td><td>128.0mV</td></tr>
<tr><td>100mV</td><td>X64</td><td>200 mV</td><td>12.80V</td></tr>
<tr><td>1V</td><td>X8</td><td>125mV</td><td>1.0V</td></tr>
<tr><td>1V</td><td>X8</td><td>2V</td><td>16.0V</td></tr>
<tr><td>10V</td><td>X1</td><td>1V</td><td>1.0V</td></tr>
<tr><td>10V</td><td>X1</td><td>19V</td><td>19.0V</td></tr>
<tr><td>100V</td><td>÷8</td><td>1V</td><td>125.0mV</td></tr>
<tr><td>100V</td><td>÷8</td><td>140V</td><td>17.50V</td></tr>
<tr><td>1000V</td><td>÷64</td><td>64V</td><td>1.0V</td></tr>
<tr><td>1000V</td><td>÷64</td><td>960V</td><td>15.0V</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>98.</td><td>Are the readings correct (noise or drift in the DC Signal Conditioner will show up on the Test DMM readings)?</td><td>100</td><td>99</td></tr>
<tr><td>99.</td><td>DC Signal Conditioner faulty. Go to Figure 4-8.</td><td></td><td></td></tr>
<tr><td>100.</td><td>Connect Test DMM HI to RT5. Repeat table in step 97. The test DMM readings should be the same.</td><td></td><td></td></tr>
<tr><td>101.</td><td>Are the Test DMM readings the same?</td><td>103</td><td>102</td></tr>
<tr><td>102.</td><td>Faulty Active Filter module. Go to Figure 4-9.</td><td></td><td></td></tr>
<tr><td>103.</td><td>Faulty A/D Converter. Go to Figure 4-10.</td><td></td><td></td></tr>
</table>

SYMPTOM	POSSIBLE FAILURE
GUARDED SUPPLY	
VA1 – BAD	U3, BR2, or Transformer
(+15V). Noisy	C3, BR2
VA2 – BAD	U4, BR2, or Transformer
(–15V) Noisy	C4, BR2
VA3 – BAD	U2, CR4, BR1, Transformer
(+30V) Noisy	C2, BR1
VA4 – BAD	U1, CR3, BR1, Transformer
(–30V) Noisy	C1, BR2
V_{CC} (Guarded)	U5, R5, R3, C5, CR1, CR2, Transformer

VA1 and VA2 are used as a reference for VA3 and VA4. VA3 and VA4 could load down VA1 and VA2. Check by lifting the reference diodes CR3 and CR4.

SYMPTOM	POSSIBLE FAILURE
UNGUARDED SUPPLY	
V_{DD} (+12V)	U6, C6, C9, C12, BR3, Transformer
V_{GG} (–12V)	U7, C13, C10, C7, BR3, Transformer
V_{CC} (+5V)	U8, R6, R4, C8, C13, C11, BR4, Transformer

The drawing below identifies the pins at the power supply edge connector. Input voltages to the regulators should be approximately 5V higher than the normal output voltages. If the output is higher or lower than specified and noise is not the problem, the regulator is bad.



UNGUARDED
TOP–60 Hz Ref, Bottom – V_{SS}
TOP–V_{DD}, Bottom–V_{GG}
Top and Bottom–V_{CC}

GUARDED
TOP–VA3, Bottom–VA4
VA2 (Top and Bottom)
VA1 (Top and Bottom)
AR (Top and Bottom)
V_{SS} (Top and Bottom)
V_{CC} (Top and Bottom)

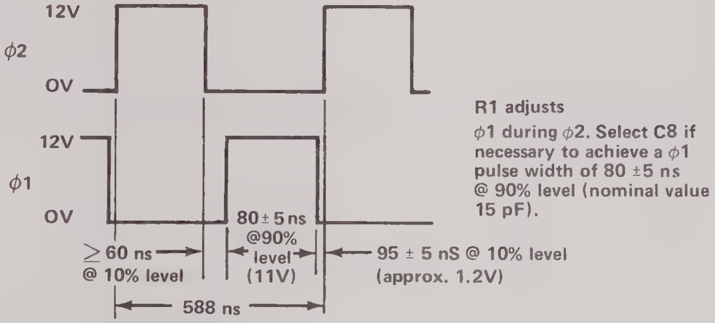
Figure 4-5. Power Supply Troubleshooting

NOTE

Due to the speed and complexity of the controller, it is recommended that, when a problem is isolated to the controller, the unit be sent to the nearest Service Center for repair. The following information will assist in troubleshooting simpler problems. Many problems require the use of a Trendar or similar tester.

SYMPTOM	POSSIBLE FAILURE
Troubleshoot the Controller with only the Controller, Front Panel, and Power Supply installed.	
Blank Display (most common symptom of controller failure)	Proceed with checks listed below

1. Check φ1 and φ2 clock at TP2, TP3



R1 adjusts φ1 during φ2. Select C8 if necessary to achieve a φ1 pulse width of 80 ±5 ns @ 90% level (nominal value 15 pF).

φ1 bad, φ2 ok	U3, U9, U10
φ1 ok, φ2 bad	U9, U10
φ1, φ2 bad	U3, U9, Y1
φ1 won't adjust	R1, U3, U9, capacitors

2. Check RST (reset) line (at U10-12, U35-13)

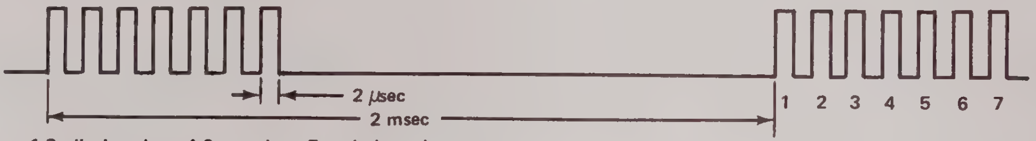
High? Check for 400 μsec delay on +5V at U36-13	
Stuck Low?	U35, U34, U36, U38

3. Check RDT (ready) line (at U10-23, U1-9)

Pulsing – OK	
Always low	clock pulse at U1-12 U1, U16, U15, U8– check inputs to U8, U18
Always high	ACK interrupt or mark interrupt not functioning properly

Figure 4-6. Controller Troubleshooting

SYMPTOM	POSSIBLE FAILURE
4. Check Bus ACK Signal.	



1-3, display clear; 4-6 new data; 7, switch read

SYMPTOM	POSSIBLE FAILURE
No pulses on ACK line	Mark interrupt circuit (U14-12, U37-3) Phase lock loop (pulses every 2 msec) IC lines output enable (U17-10) IC lines output gates (U29, U37)
ACK always high	U38, CR1, C27
5. Check IB OUT (U17-9) — is data going out?	
6. Check A15, WAIT, WR, and DBIN lines	U10, ROM enable, ROM decoders, ROM
7. Check address and data lines at U10 for being held high or low all the time.	
8. If MARKS, INT, INTE OK, INT VECTOR (U28, U19, U37) may be bad giving wrong vector information.	
OTHER PROBLEMS	
Won't read switches	IC6 bad (no ACK) or bad data in
Displays all modules present (CXXXXX)	ACK INT CKT, ACK held high
Wrong display	Data bad, IC line always high
Won't respond to external interrupts	U17 (INT), U37, U32 (INA) U28, U19, U23 (INT Vector wrong)

Figure 4-6. Controller Troubleshooting (cont)

SYMPTOM	POSSIBLE FAILURE
No ACK Pulse	U28, U19 (Address Decoders) U23 (Indirect F/F) U19, U11, Q10 (ACK Circuit)
No Display (ACK Pulse Present)	U18 (Kill Circuit)
No Response to Switch Pushes (Display Good)	Switch Associated With Function U32, CR1 — CR4 Open
Segment Bad In All LEDs	Check Path from Latch to Transistor Drivers to LED Cathodes
One LED Doesn't Light	Check Path From Latch To Inverter to Transistor Drivers to LED Anode
Segment or Decimal Missing On Only One LED	Bad LED
Display Gives Wrong Numbers, One LED Brighter	U11 (Reset to Indirect Address F/F, U23) Address Decoder. (Problem is Indicative of Front Panel Responding to an Invalid Address.)

Figure 4-7. Front Panel Troubleshooting

SYMPTOM	POSSIBLE FAILURE
DC Inoperative All Ranges	Digital Control Logic Q8, Q6, Q7, Open K1, Q1, Q2 Open; Q18, Q19, U3 Bad
Display Blanks	U1 or U2
Locks in Overrange	U3
Reading Drifts	U4; Q14, Q15, Q16 Leaky
Won't Zero	U5 or U6
100 mV Range Bad	Q31, Q32, Q14
1V and 100V Range Bad	Q33, Q34, Q15
100V and 1000V Range Bad	K2, Q3, Q4
Random Readings	K1 Open, K2 Shorted
Nonlinear Readings	Q16, Q15, Q14 Leaky

ADDRESS AND DATA FIELD

ADDRESS	IB DATA DURING ADDRESS				
	ID3	ID2	ID1	ID0	
IC4, IC3, IC0 = 1	0	1	1	0	100 mV Range G = 64
	1	0	1	0	1V Range G = 8
	1	1	0	1	10V Range G = 1
	1	0	0	0	100V Range G = ÷8 (÷64 x 8)
	1	1	0	0	100V Range G = ÷64

ID3 - ID4 = Control Amplifier Gain

0 1 = x 64
1 0 = x 8
1 1 = z 1

RT1 inputs controlled as follows for OHMS & ADC

ADDRESS	DATA				
	ID3	ID2	ID1	ID0	
IC4, IC3, IC0 = 1	0	1	0	1	G = x 64
	1	0	0	1	G = x 8
	1	1	0	1	G = x 1

NOTE

If R54 R57, Q18, Q19 or Q22 are replaced it will be necessary to return the module to the factory (attn. PARTS) to be temperature compensated anew.

Figure 4-8. DC Signal Conditioner Troubleshooting

SYMPTOM	POSSIBLE FAILURE
High Zero Offset	Q32, Q25, Q19, Q20 Shorted
DC Inoperative	Q18 Open – Q21, Q22, Q23, Q24 Open Q27, U5 Digital Logic
Overrange	U5 – Q19, Q20 Shorted
Noisy	
All Ranges	
Either Filter	Q25, Q32 Leaky – Q31, U5 Bad
Slow Filter (ON)	Q21, Q22 Leaky – U4 Bad
Fast Filter (OFF)	Q23, Q24 Leaky – U3 Bad
Nonlinear Readings	U5
Display Blanks	U1 Or U2

ADDRESS AND DATA FIELD

ADDRESS	DATA
IC4, IC3, & IC1 = 1	ID0 = 1 Filter By Pass (Remote Only) ID1 = 1 Z Filter (F.P. Light On) ID2 = 1 Y Filter (F.P. Light Off) ID3 = 1 Filter - Always on except In Ext. Ref. ID4 = 1 Ext. Ref. Lo ID5 = 1 Ext. Ref. Hi

Adjustment of R14

1. Short the 8502A input terminals.
2. Short RT6 to RT2 on the Bus Interconnect Monitor.
3. Adjust R14 for a reading of ±.000000 ±2 digits. (This requires that the A/D Converter is working accurately.)

Selection of R15 or R16.

If Q27 or U5 have been replaced, R15 and R16 will require reselection if adjustment of R14 does not zero the reading.

1. Only one of R15 and R16 will be installed. Replace whichever is installed with a short.
2. Connect the R15 short to the R16 short.
3. Short RT6 to RT2 on the Bus Interconnect Monitor.
4. Connect the test DMM HI to TP3 and LO to TP1 on the Active Filter module.
5. Select a resistor from the table below according to the measured offset. If the polarity is positive, install the resistor as R16; if negative as R15. (Maximum allowable offset in this step is 5200 μV.)

OFFSET (μV)	RESISTOR	FLUKE PART NO.
0-400	None	
401-1200	31.6K	261610
1201-2000	63.4K	235382
2001-2800	97.6K	241380
2801-3600	133.0K	289074
3601-4400	165.0K	376186
4401-5200	205.0K	375931

6. After installing the resistor, adjust R14.

Figure 4-9. Active Filter Troubleshooting

DIGITAL BOARD

SYMPTOM	POSSIBLE FAILURE
Display Blanks	U33, U34, U35 (Affecting ID Lines)
Improper Readings, Inoperative A/D, Nonlinear Readings	Check Transistor Array Outputs to J1 and J2 – The Rise and Fall Times of These Switching Pulses Must be <2 μsec.
Flickering Display	Autozero Control – U25, U34
Direct Address	
IC 4, 3, & 2 High	ID0 = 1 = Reset Counter ID1 = 1 = Auto Zero ID2 = 0 = Buffer Input ID2 = 1 = Remainder Input ID3 = 1 = Channel X (Auto Zero and Remainders 1 and 3) ID3 = 0 = Channel Y (Remainders 2 and 4)
Indirect Address	
IC 2 & 1 High (and Ring Counter Not in C0 Time period, C0 = 0)	This Indirect Address allows the ID7 Enable to bring back Polarity Bits to the Controller Module

ANALOG BOARD

First Check TP5 – Should be switching between + and –7V. Typical failures in this circuit result in a portion of the switching slope having a slew rate less than 1V/μsec. A glitch at the zero point is normal.

SYMPTOM	POSSIBLE FAILURE
Noisy Readings	U1, U2, U3
Nonlinear Ladder	U4, Q9, Q10 (Q27)
Ladder Out Of Tolerance	FETS Q11 – Q15 or Q17 – Q21
All Digits Wrong	U7, Q31, Q32
Reading Locked (Doesn't Respond To Input Change) Or Always Overrange	U4, Q9, U1, U2, U3, Q2, Q3
Bad Remainders (Lesser Digits)	Q22, U4, U6
No Polarity Bit Returned	Q29, Q28
Shifty Readings (Most Or All Digits)	Autozero Settling Time Problems U8, Q30 – Q8, Q7

NOTE

If U1, R9, R14-R16, R34, R35, R50-55, R67, Q1-Q3, Q11-Q16, Q25, or Q26 are replaced it will be necessary to return the module to the factory (attn. PARTS) to be temperature compensated anew.

Figure 4-10. R^2 A/D Converter Troubleshooting

Section 5

List of Replaceable Parts

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5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the mainframe instrument. A parts breakdown for each of the optional modules is contained in the subsection of Section 6 pertaining to the module. Components are listed alpha-numerically by assembly. Both electrical and mechanical components are listed first by reference designation and second by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

1. Reference Designation or Item Number.
2. Description of each part.
3. FLUKE Stock Number.
4. Federal Supply Code for Manufacturers. (See Section 7 for Code-to-Name list.)
5. Manufacturer's Part Number or Type.
6. Total Quantity per assembly or component.
7. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

1. Quantity.
2. FLUKE Stock Number.
3. Description.
4. Reference Designation or Item Number.
5. Printed Circuit Board Part Number.
6. Instrument Model and Serial Number.

5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY

CAUTION

Indicated devices are subject to damage by static discharge.

Table 5-1. Final Assembly 15 Inch Pack

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	FINAL ASSY, 8502A 15 INCH PACK FIGURE 5-1 (8502A-5001/T&B)						
A2	MOTHER BOARD PCB ASSY	481713	89536	481713	1		
A3	BUS INTERCONNECT PCB ASSY	459636	89536	459636	1		
A4	POWER SUPPLY PCB ASSY	ORDER	FOR	APPROPRIATE SOURCE	1		1
A5	POWER SUPPLY INTERCONNECT ASSY	401760	89536	401760	1		
A6	CONTROLLER ASSY	384024	89536	384024	1		2
A6.	CONTROLLER ASSY	577072	89536	577072	1		
A7	FRONT PANEL ASSY	481689	89536	481689	1		
A8	DC SIGNAL CONDITIONER PCB ASSY	383901	89536	383901	1		
A9	ACTIVE FILTER PCB ASSY	383976	89536	383976	1		
A10	FAST R^2 A/B CONVERTER PCB ASSY	383984	89536	383984	1		
E1	POST, BINDING, HEAD GRNDING	225615	20584	3575	1		
E2	POST, BINDING, GRNDING	225623	20584	3576	1		
H1	NUT, HEX, DOUBLE CHAMFER 1/4-28	110619	89536	110619	1		
H2	NUT, HEX, STOP	110841	89536	110841	1		
H3	SHORTING LINK	190728	83330	21171	3		
H5	SCREW, CAP, LO HEAD SOCKET #8	295105	74445	8-32UNRC	4		
H6	SCREW, FHP, COUNTERSUNK	114116	73734	20254	8		
H7	SCREW, PHP, 4-40 X 1/4	129882	73734	19022	11		
H8	SCREW, FH, UNDERCUT, 6-32 X 1/4	320093	89536	320093	6		
H9	SCREW, PHP, 8-32 X 5/8	293324	73734	23067	2		
H10	SCREW, PHP, SEMS, 6 - 32 X 1/2	177030	89536	177030	9		
H11	SCREW, FHP, COUNTERSINK 8 - 32 X 1/2	114355	73734	18266	3		
H12	WASHER, LOCK, INT TOOTH #8	110320	73734	1305	2		
H13	WASHER, LOCK, INTERNAL 1/4	110817	89536	110817	1		
MP1	BAIL, FULL WIDTH	231407	89536	231407	1		
MP2	BEZEL, I/O	416206	89536	416206	1		
MP3	BRACKET, INNER, CHASSIS LEFT	496372	89536	496372	1		
MP4	BRACKET, INNER, CHASSIS RIGHT	496380	89536	496380	1		
MP5	BUTTON, PLUG	101774	89536	101774	1		
MP6	BUTTON, PWR SWITCH	401646	89536	401646	1		
MP7	CHASSIS ASSY	481275	89536	481275	1		
MP8	CENTER SUPPORT ASSEMBLY	576637	89536	576637	1		
MP10	CORNER, FINISHED	394346	89536	394346	2		
MP11	CORNER, HANDLE	394304	89536	394304	2		
MP12	CONTACT STRIP	370619	30817	97-500-A	AR		
MP13	COVER, BOTTOM				1		
	BLUE	383265	89536	383265	REF		
	PUTTY GREY	522722	89536	522722	REF		
MP14	COVER PLATE, INPUT	420679	89536	420679	1		
MP15	DECAL, REAR PANEL	473413	89536	473413	1		
MP16	DECAL, SIDE TRIM, FWD	525980	89536	525980	2		
MP17	DECAL, CORNER	394387	89536	394387	4		
MP18	DECAL, FRONT PANEL	477538	89536	477538	1		
MP19	DECAL, SERIAL NO.	393975	89536	393975	1		
MP20	EXTRUSION, PCB RETAINER	408476	89536	408476	1		
MP21	FOOT, BAIL STAND	292870	89536	292870	4		
MP22	FOOT, REAR PANEL	307363	89536	307363	2		

Table 5-1. Final Assembly 15 Inch Pack (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP23	HOLDER, INSTRUCTION BOOK	427534	89536	427534	1		
MP24	INSERT, FRONT PANEL	381871	89536	381871	1		
MP25	INSTRUCTION PAGE ASSY	458281	89536	458281	1		
MP26	STANDOFF, INSULATED	494922	89536	494922	1		
MP27	LENS DISPLAY, SCREENED	485870	89536	485870	1		
MP28	COVER, TOP	522516	89536	522516	1		
P1	PLUG, SWITCH	437855	89536	437855	1		
TM1	INSTRUCTION MANUAL, 8502A	471466	89536	471466	1		
W1	CORD SET (NOT SHOWN)	284174	89536	284174	1		
	RECOMMENDED SPARE PARTS KIT	503599	89536	503599	AR		

1 EITHER OF THE A4 PCB ASSYS. MAY BE INSTALLED ON THIS UNIT.

2 EITHER OF THE A6 PCB ASSYS. MAY BE INSTALLED ON THIS UNIT.

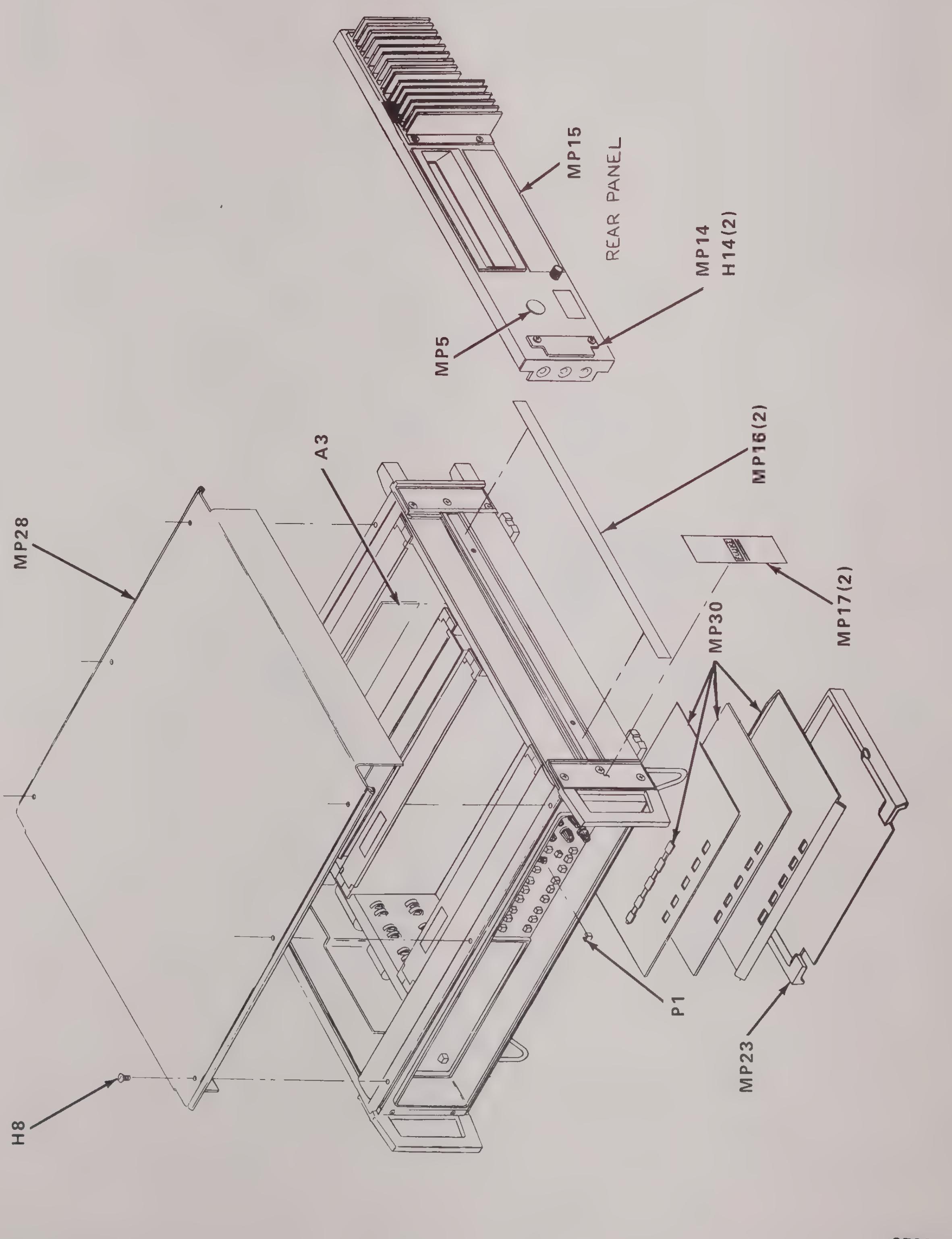

MP15
REAR PANEL
MP14
H14(2)
MP5
A3
MP16(2)
MP28
MP17(2)
MP30
P1
MP23
H8
8502A

Figure 5-1. Final Assembly 15 Inch Pack

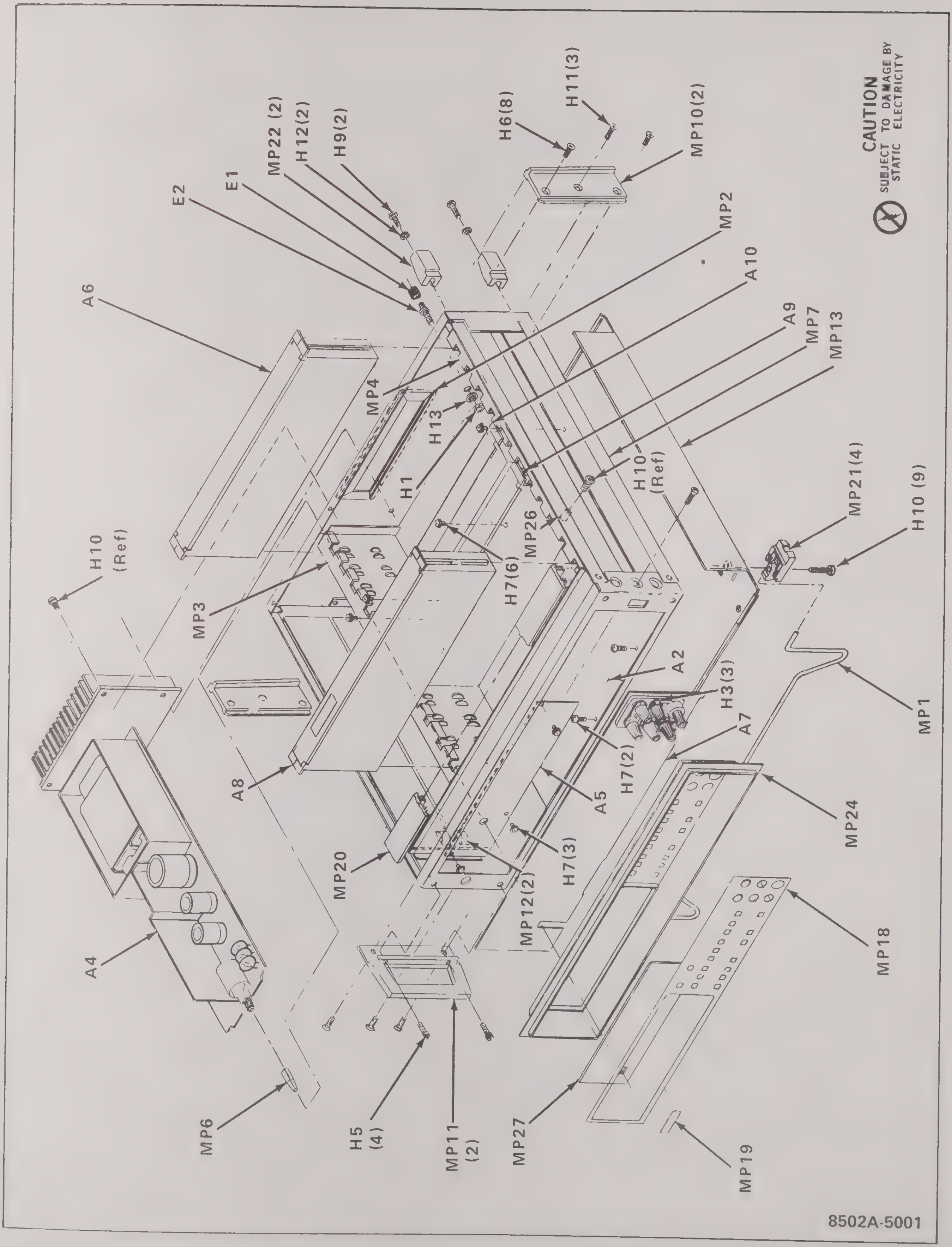

A6
E2
E1
MP22 (2)
H12(2)
H9(2)
H6(8)
H11(3)
MP10(2)
CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY
MP2
A10
A9
MP7
MP13
MP4
H13
H1
H10
(Ref)
MP26
H7(6)
MP21(4)
H10 (9)
H10
(Ref)
MP3
A2
H3(3)
MP1
A7
H7(2)
A8
A5
MP24
MP20
H7(3)
MP12(2)
MP18
A4
MP6
H5
(4)
MP11
(2)
MP27
MP19
8502A-5001

Figure 5-1. Final Assembly 15 Inch Pack (cont)

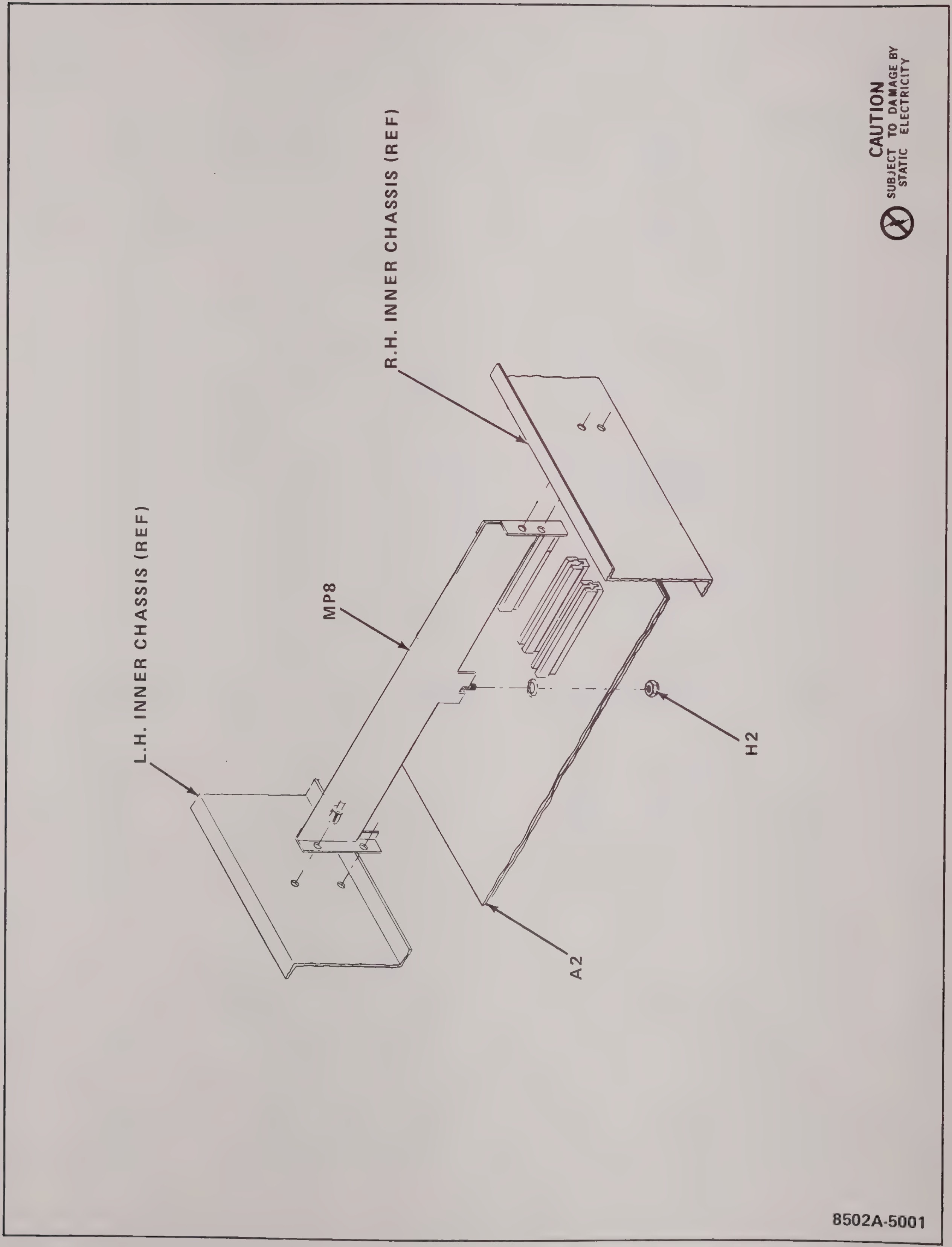

L.H. INNER CHASSIS (REF)
MP8
R.H. INNER CHASSIS (REF)
H2
A2
CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY
8502A-5001

Figure 5-1. Final Assembly 15 Inch Pack (cont)

Table 5-2. A2 Motherboard PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A2	MOTHERBOARD PCB ASSEMBLY FIGURE 5-2 (8502A-4001T)	481713	89536	481713	REF		
H1	NUT, HEX DOUBLE CHAMFER 4-40	184044	73734	8002A-NP	2		
H2	SCREW, PHP, 4-40 X 1	157008	73734	19030	2		
H3	WASHER, FLAT #4	146225	86926	5710-18-32	2		
H4	WASHER, LOCK, INT TOOTH	110403	73734	99402	2		
H5	WASHER, FLAT, #8	110270	73734	1406	2		
H6	WASHER, SPLIT, LOCK	403923	89536	403923	2		
J1	CONNECTOR, BD EDGE RECPT, 8 PIN	354951	00779	583407-5	2		
J2	CONNECTOR, BD EDGE RECPT, 18 PIN	291906	00779	583650-3	1		
J6	CONNECTOR, BD EDGE RECPT, 20 PIN	291914	00779	583650-4	1		
J7	CONNECTOR, BD EDGE RECPT, 8 PIN	354951	00779	583407-5	REF		
J8	CONNECTOR, BD EDGE RECPT, 4 PIN	417550	89536	417550	6		
J11A	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	12		
J11B	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J11C	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J11D	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J12A	CONNECTOR, BD EDGE RECPT, 6 PIN	291625	00779	583650-1	4		
J12B	CONNECTOR, BD EDGE RECPT, 6 PIN	291625	00779	583650-1	REF		
J12C	CONNECTOR, BD EDGE RECPT, 6 PIN	291625	00779	583650-1	REF		
J12D	CONNECTOR, BD EDGE RECPT, 6 PIN	291625	00779	583650-1	REF		
J21G	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J22H	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J23H	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J27	CONNECTOR, BD EDGE RECPT, 10 PIN	403964	00779	583407-6	1		
J28	CONNECTOR, BD EDGE RECPT, 4 PIN	417550	89536	417550	REF		
J29K	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J30K	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J31A	CONNECTOR, BD EDGE RECPT, 4 PIN	417550	89536	417550	REF		
J31B	CONNECTOR, BD EDGE RECPT, 4 PIN	417550	89536	417550	REF		
J31C	CONNECTOR, BD EDGE RECPT, 4 PIN	417550	89536	417550	REF		
J31D	CONNECTOR, BD EDGE RECPT, 4 PIN	417550	89536	417550	REF		
J31L	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J31M	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J31N	CONNECTOR, BD EDGE RECPT, 40 PIN	422550	00779	2-583407-0	REF		
J41	BINDING POST, BLK	493973	32767	820-45	1		
J42	BINDING POST, RED	493981	32767	820-65	1		
MP1	TERMINAL BLOCK	419663	89536	419663	1		
P43	AMP POST	267500	00779	87022-1	2		
R1	RESISTOR, MF, 1/2W, 30.9K	247569	91637	MFF1-23092F	2		
R2	RESISTOR, MF, 1/2W, 30.9K	247569	91637	MFF1-23092F	REF		
R3	RES, DEP CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	1		
XJ2	POLARIZING INSERT	293498	00779	530030-1	14		
XJ6	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ11A	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ11B	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ11C	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ11D	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ21G	POLARIZING INSERT	293498	00779	530030-1	REF		

Table 5-2. A2 Motherboard PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
XJ22H	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ23H	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ27	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ29K	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ31L	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ31M	POLARIZING INSERT	293498	00779	530030-1	REF		
XJ31N	POLARIZING INSERT	293498	00779	530030-1	REF		

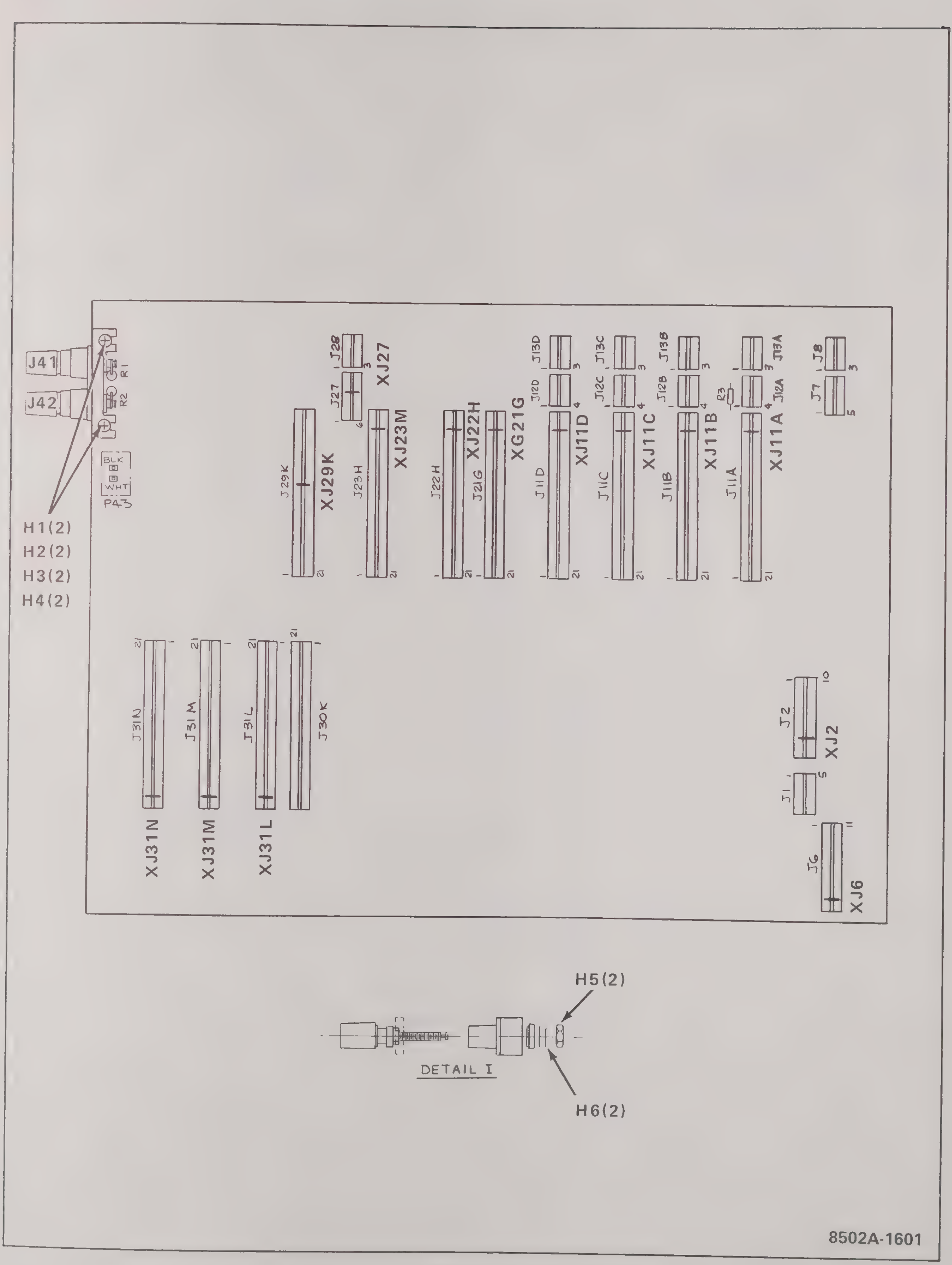
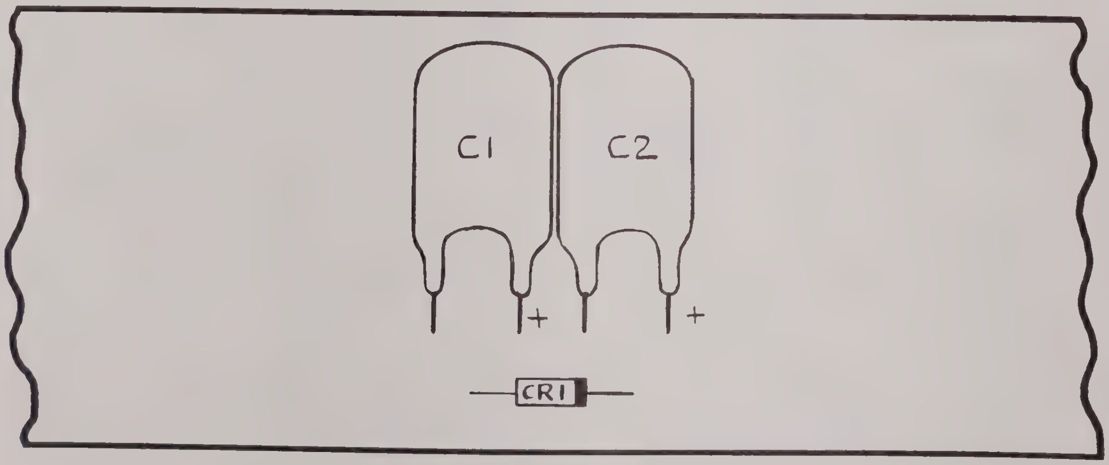

J41
J42
R1
R2
BLK
WHT
P43
H1(2)
H2(2)
H3(2)
H4(2)
J28
J27
XJ27
J29K
XJ29K
J23H
XJ23M
J22H
XJ22H
J21G
XG21G
J13D
J12D
J11D
XJ11D
J13C
J12C
J11C
XJ11C
J13B
J12B
J11B
XJ11B
R3
J13A
J12A
J11A
XJ11A
J8
J7
J31N
XJ31N
J31M
XJ31M
J31L
XJ31L
J30K
J2
XJ2
J1
J6
XJ6
H5(2)
H6(2)
DETAIL I
8502A-1601

Figure 5-2. A2 Motherboard PCB Assembly

Table 5-3. A3 Bus Interconnect PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A3	BUS INTERCONNECT PCB ASSEMBLY FIGURE 5-3 (MIS-4081)	459636	89536	459636	REF		
C1	CAP, TA, 220 UF +/-20%, 6V	408682	56289	196D227X0006TE4	2		
C2	CAP, TA, 220 UF +/-20%, 6V	408682	56289	196D227X0006TE4	REF		
CR1	DIODE, SI, RECT, 1 AMP	343491	01295	1N4002	1	1	



MIS-1681

Figure 5-3. A3 Bus Interconnect PCB Assembly

Table 5-4. A4 Power Supply PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A4	POWER SUPPLY PCB ASSEMBLY	ORDER	FOR	APPROPRIATE SOURCE	REF		1
	POWER SUPPLY ASSY, 115/230V	448886	89536	448886			
	POWER SUPPLY ASSY, 100V	456996	89536	456996			
	FIGURE 5-4 (8500A-4041T)						
BR1	BRIDGE, RECTIFIER	296509	09423	FB200	3	1	
BR2	BRIDGE, RECTIFIER	296509	09423	FB200	REF		
BR3	BRIDGE, RECTIFIER	296509	09423	FB200	REF		
BR4	BRIDGE, RECTIFIER	428839	09713	MDA970-1	1	1	
C1	CAP, ELECT, 470 UF -10/+50%, 40V	185868	73445	ET471Z040-A02	2	1	
C2	CAP, ELECT, 470 UF -10/+50%, 40V	185868	73445	ET471Z040-A02	REF		
C3	CAP, ELECT, 220 UF -10/+50%, 40V	178616	80031	ET221X040-A01	2		
C4	CAP, ELECT, 220 UF -10/+50%, 40V	178616	80031	ET221X040-A01	REF		
C5	CAP, ELECT, 2200 UF -10/+100%, 25V	448126	12674	61C25BAS-252	2	1	
C6	CAP, ELECT, 4000 UF -10/+100%, 25	370734	99372	3044TS043U025	1	1	
C7	CAP, ELECT, 2200 UF -10/+100%, 25V	448126	12674	61C25BAS-252	REF		
C8	CAP, ELECT, 15000 UF -10/+100%, 15V	407940	99372	3044HA1534015	1	1	
C9	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X-0025KA1	4		
C10	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X-0025KA1	REF		
C11	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X-0025KA1	REF		
C12	CAP, CER, 0.1 UF +/-20%, 100V	149146	56289	33C41B6	3		
C13	CAP, CER, 0.1 UF +/-20%, 100V	149146	56289	33C41B6	REF		
C14	CAP, CER, 0.1 UF +/-20%, 100V	149146	56289	33C41B6	REF		
C15	CAP, CER, 0.005 +/-20%, 3KV	188003	71590	2DDH6R502M	2		
C16	CAP, CER, 0.005 +/-20%, 3KV	188003	71590	2DDH6R502M	REF		
C17	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X-0025KA1	REF		
CR1	DIODE, RECT, SI, 50V	347559	05277	1N5400	3	1	
CR2	DIODE, RECT, SI, 50V	347559	05277	1N5400	REF		
CR3	DIODE, RECT, SI, 100V	343491	01295	1N4002	2	1	
CR4	DIODE, RECT, SI, 100V	343491	01295	1N4002	REF		
CR5	DIODE, RECT, SI, 50V	347559	05277	1N5400	REF		
F1	FUSE, SLO BLO, 1/2 AMP	109322	71400	MDL1-2	1	5	
H1	SCREW, PHP, 4-40 X 5/8	145813	89536	145813	2		
H2	SCREW, PHP, 8-32 X 3/8	436030	89536	436030	2		
H3	NUT, HEX, 8-32	110544	89536	110544	2		
H4	WASHER, INT/LOCK, #8	110320	89536	110320	2		
H5	SCREW, RHP, 8-32 X 3/8	114124	89536	114124	2		
H6	SCREW, PHP, 4-40 X 1/4 (NOT SHOWN)	129890	89536	129890	1		
H7	SCREW, PHP, 2-56 X 3/4	196840	89536	196840	1		
H8	SCREW, PHP, 4-40 X 1/2 (NOT SHOWN)	152132	89536	152132	2		
H9	SCREW, PHP, 4-40 X 3/8 (NOT SHOWN)	152124	89536	152124	2		
H10	WASHER, FLAT (NOT SHOWN)	110775	89536	110775	3		
H11	NUT, HEX, 4-40 (NOT SHOWN)	184044	89536	184044	8		
H12	WASHER, INT/LOCK #4 (NOT SHOWN)	110403	89536	110403	5		
H13	WASHER, SHOULDER (NOT SHOWN)	436386	86928	5607-45	5		
J1	CONNECTOR, POWER RECEPTACLE	284166	82389	EAC301	1		
MP1	DECAL (NOT SHOWN)	386250	89536	386250	1		
MP2	EXTRUSION (NOT SHOWN)	416974	89536	416974	1		
MP3	FERRITE CORE (NOT SHOWN)	420588	89536	420588	1		
MP4	INSULATOR, POWER SWITCH (NOT SHOWN)	383158	89536	383158	1		

Table 5-4. A4 Power Supply PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP5	INSULATOR, SEMICONDUCTOR MTG (NOT SHOWN)	508630	55285	7403-09-FR-51	5		
MP6	INSULATOR GASKET (NOT SHOWN)	436824	89536	436824	1		
MP7	HEATSINK (NOT SHOWN)	386235	13103	6032D	1		
MP8	HEAT DISSIPATOR (U1,U2) NOT SHOWN	414128	13103	6030B-TT	2		
MP9	NUTPLATE (NOT SHOWN)	420448	89536	420448	1		
MP10	BRACKET	166322	73734	1552	2		
MP11	LUG, SOLDER	102558	79963	124	1		
MP12	SHIELD ASSEMBLY	450502	89536	450502	1		
MP13	SCREW, CAPTIVE, 4-40 X 1/2 (NOT SHOWN)	293316	24347	FH-440-8	1		
R1	RES, DEP. CAR, 3.3K +/-5%, 1/4W	348813	80031	CR251-4-5P3K3	2		
R2	RES, DEP. CAR, 3.3K +/-5%, 1/4W	348813	80031	CR251-4-5P3K3	REF		
R3	RES, DEP. CAR, 390 +/-5%, 1/4W	441543	80031	CR251-4-5P390E	2		
R4	RES, DEP. CAR, 390 +/-5%, 1/4W	441543	80031	CR251-4-5P390E	REF		
R5	RES, VAR, CERMET, 50 +/-20%, 1/2W	320861	02111	62-1-1-500	2	1	
R6	RES, VAR, CERMET, 50 +/-20%, 1/2W	320861	02111	62-1-1-500	REF		
R7	RES, DEP. CAR, 240 +/-5%, 1/4W	376624	80031	CR251-4-5P240E	1		
R8	RES, DEP. CAR, 2K +/-5%, 1/4W	441493	80031	CR251-4-5P2K	1		
R9	RES, VAR, CERMET 500 +/-20%, 1/2W	226068	02111	62-1-1-501	1	1	
S1	SWITCH, SLIDE, DPDT (115/230V)	376798	82389	11A1437	1	1	
S2	SWITCH, POWER, DPDT	291526	89536	291526	1	1	
T1	TRANSFORMER HEADER ASSEMBLY	ORDER	FOR	APPROPRIATE SOURCE	1		
	115/230V	450403	89536	450403			
	100V	456350	89536	456350			
U1	IC, LIN, VOL REG	413187	04713	MC7815CP	2	1	
U2	IC, LIN, NEG, VOL REG	413179	04713	MC7915CP	2	1	
U3	IC, LIN, ADJ VOLT REGULATOR	460410	12040	LM317T	1	1	
U4	IC, LIN, NEG, VOL REG	413179	04713	MC7915CP	REF		
U5	IC, LIN, VOL REG	355107	04713	MC7805CP	1	1	
U6	IC, LIN, VOL REG	428854	04713	MC7812CP	1	1	
U7	IC, LIN, NEG, VOL REG	381665	04713	MC7912CP	1	1	
U8	IC, LIN, VOL REG	428847	04713	MC7805CP	1	1	
XF1	FUSEHOLDER	435628	89536	435628			
XU4	SOCKET, IC (NOT SHOWN)	402958	27264	10-18-2031	3		
XU5	SOCKET, IC (NOT SHOWN)	402958	27264	10-18-2031	REF		
XU6	SOCKET, IC (NOT SHOWN)	402958	27264	10-18-2031	REF		

1 EITHER OF THE A4 PCB ASSYS. MAY BE INSTALLED IN THIS UNIT.

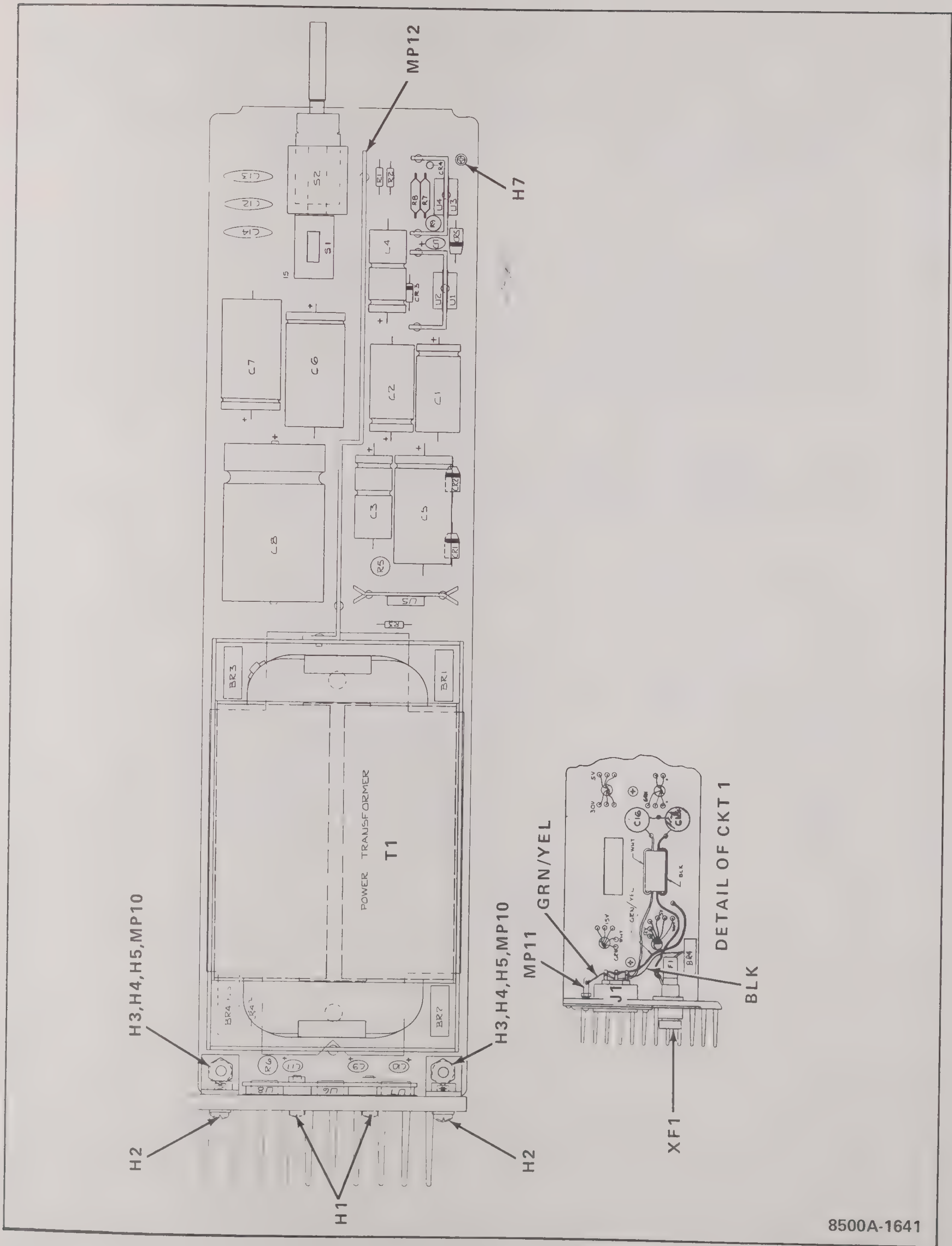

MP12
H7
S2
S1
C7
C6
C2
C1
C3
C5
C8
L4
U1
U2
U3
U4
U5
R5
BR1
BR2
BR3
BR4
POWER TRANSFORMER
T1
H3,H4,H5,MP10
H3,H4,H5,MP10
MP11
GRN/YEL
DETAIL OF CKT 1
C16
J1
BLK
XF1
H2
H2
H1
8500A-1641

Figure 5-4. A4 Power Supply PCB Assembly

Table 5-5. A4 Power Supply PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A4	POWER SUPPLY PCB ASSEMBLY	ORDER	FOR	APPROPRIATE SOURCE	REF		1
	POWER SUPPLY ASSY, 115/230V MODEL	608638	89536	608638			
	POWER SUPPLY ASSY, 100V MODEL	456988	89536	456988			
	FIGURE 5-5 (8500A-4051T)						
BR1	BRIDGE, RECTIFIER	296509	09423	FB200	3	1	
BR2	BRIDGE, RECTIFIER	296509	09423	FB200	REF		
BR3	BRIDGE, RECTIFIER	296509	09423	FB200	REF		
BR4	BRIDGE, RECTIFIER	586115	14936	KBL 005	1		
C1	CAP, ELECT, 470 UF -10/+50%, 50V	478792	89536	478792	4		
C2	CAP, ELECT, 470 UF -10/+50%, 50V	478792	89536	478792	REF		
C3	CAP, ELECT, 330 UF -10/+25%, 50V	484436	89536	484436	2		
C4	CAP, ELECT, 330 UF -10/+25%, 50V	484436	89536	484436	REF		
C5	CAP, ELECT, 3300 UF -10/+100%, 25V	603472	89536	603472	1		
C6	CAP, ELECT, 470 UF -10/+50%, 50V	478792	89536	478792	REF		
C7	CAP, ELECT, 470 UF -10/+50%, 50V	478792	89536	478792	REF		
C8	CAP, ELECT, 15000 UF -10/+100%, 15V	603480	89536	603480	1		
C9	CAP, TA, 5.6UF +/-20%, 25V	368969	56289	196D565X-0025KA1	4		
C10	CAP, TA, 5.6UF +/-20%, 25V	368969	56289	196D565X-0025KA1	REF		
C11	CAP, TA, 5.6UF +/-20%, 25V	368969	56289	196D565X-0025KA1	REF		
C12	CAP, CER, 0.1UF +/-20%, 100V	149146	56289	33C41B6	3		
C13	CAP, CER, 0.1UF +/-20%, 100V	149146	56289	33C41B6	REF		
C14	CAP, CER, 0.1UF +/-20%, 100V	149146	56289	33C41B6	REF		
C15	CAP, CER, 0.005 +/-20%, 3KV	485839	89536	485839	2		
C16	CAP, CER, 0.005 +/-20%, 3KV	485839	89536	485839	REF		
C17	CAP, TA, 5.6UF +/-20%, 25V	368969	56289	196D565X-0025KA1	REF		
CR1	DIODE, RECT, SI, 50V	347559	05277	1N5400	3	1	
CR2	DIODE, RECT, SI, 50V	347559	05277	1N5400	REF		
CR3	DIODE, RECT, SI, 100V	343491	14099	SI-1	2	1	
CR4	DIODE, RECT, SI, 100V	343491	01295	1N4002	REF		
CR5	DIODE, RECT, SI, 50V	347559	05277	1N5400	REF		
F1	FUSE, SLO BLO, 1/2 AMP	109322	71400	MDL1-2	1	5	
H1	SCREW, PHP, 2-56 X 3/4	196840	89536	196840	2		
H2	SCREW, P[HP, 4-40 X 1/4 (NOT SHOWN)	129890	89536	129890	5		
H3	SCREW, PHP, 4-40 X 1/2	152132	89536	152132	2		
H4	SCREW, PHP, 4-40 X 5/8	145813	89536	145813	2		
H5	SCREW, PHP, 8-32 X 3/8	114124	89536	114124	2		
H6	SCREW, PHP, 8-32 X 3/8	436030	89536	436030	2		
H7	NUT, HEX, 4-40	184044	89536	184044	8		
H8	NUT, HEX, #8	110544	89536	110544	2		
H9	WASHER, LOCK #4	110403	89536	110403	5		
H10	WASHER, LOCK #8	110320	89536	110320	2		
H11	WASHER, SHOULDER (NOT SHOWN)	436386	89536	436386	5		
H12	WASHER, FLAT #2 (NOT SHOWN)	110775	89536	110775	3		
J1	CONNECTOR, POWER RECEPTACLE	284166	82389	EAC301	1		
MP1	DECAL (NOT SHOWN)	386250	89536	386250	1		
MP2	BRACKET	166322	73734	1552	1		
MP3	FERRITE CORE (NOT SHOWN)	420588	89536	420588	1		
MP4	INSULATOR, POWER SWITCH (NOT SHOWN)	383158	89536	383158	1		
MP5	INSULATOR, SEMICONDUCTOR MTG (NOT SHOWN)	508630	55285	7403-09-FR-51	5		

Table 5-5. A4 Power Supply PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP6	INSULATOR GASKET (NOT SHOWN)	436824	89536	436824	1		
MP7	NUTPLATE	420448	89536	420448	1		
MP8	HEATSINK	608752	89536	608752	1		
MP9	HEATSINK (NOT SHOWN)	386235	13103	6032D	1		
MP10	HEATSINK	416974	89536	416974	1		
MP11	SHIELD ASSEMBLY	450502	89536	450502	1		
MP12	LUG, SOLDER	102558	79963	124	2		
MP13	STUD, 4-40 X 1/2	293316	89536	293316	1		
R1	RES, DEP. CAR, 3.3K +/-5%, 1/4W	348813	80031	CR251-4-5P3K3	1		
R3	RES, DEP. CAR, 490 +/-5%, 1/4W	441543	80031	CR251-4-5P490E	2		
R4	RES, DEP. CAR, 490 +/-5%, 1/4W	441543	80031	CR251-4-5P490E	REF		
R5	RES, VAR, CERMET, 50 +/-20%, 1/2W	320861	02111	62-1-1-500	2	1	
R6	RES, VAR, CERMET, 50 +/-20%, 1/2W	320861	02111	62-1-1-500	REF		
R7	RES, DEP. CAR, 240 +/-5%, 1/4W	376624	80031	CR251-4-5P240E	1		
R8	RES, DEP. CAR, 2.4K +/-5%, 1/4W	441493	80031	CR251-4-5P2K4	1		
R9	RES, VAR, 500 +/-20%, 1/2W	226068	19701	501	1	1	
S1	SWITCH, SLIDE, DPDT (115/230V)	376798	82389	11A1437	1	1	
S2	SWITCH, POWER	291526	89536	291526	1	1	
T1	TRANSFORMER HEADER ASSEMBLY	ORDER	FOR	APPROPRIATE SOURCE	1		
	115/230V	450403	89536	450403			
	100V	456350	89536	456350			
TP1	CONNECTOR, FASTON TAP	512889	00779	62395-1	10		
TP2	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP3	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP4	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP5	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP6	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP7	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP8	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP9	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
TP10	CONNECTOR, FASTON TAP	512889	00779	62395-1	REF		
U1	IC, LIN, VOL REG	413187	04713	MC7815CP	2	1	
U2	IC, LIN, NEG, VOL REG	413179	04713	MC7915CP	2	1	
U3	IC, LIN, ADJ VOLT REGULATOR	460410	12040	LM317T	1	1	
U4	IC, LIN, NEG, VOL REG	413179	04713	MC7915CP	REF		
U5	IC, LIN, VOL REG	355107	04713	MC7805CP	1	1	
U6	IC, LIN, VOL REG	428854	04713	MC7812CP	1	1	
U7	IC, LIN, NEG, VOL REG	381665	04713	MC7912CP	1	1	
U8	IC, LIN, VOL REG	428847	04713	MC7805CP	1	1	
XF1	FUSEHOLDER, W/NUT	375188	89536	375188	1		
	FUSE CAP	460238	89536	460238	1		
XU4	SOCKET, IC	402958	27264	10-18-2031	3		
XU5	SOCKET, IC	402958	27264	10-18-2031	REF		
XU6	SOCKET, IC	402958	27264	10-18-2031	REF		

1 EITHER OF THE A4 PCB ASSYS. MAY BE INSTALLED IN THIS UNIT.

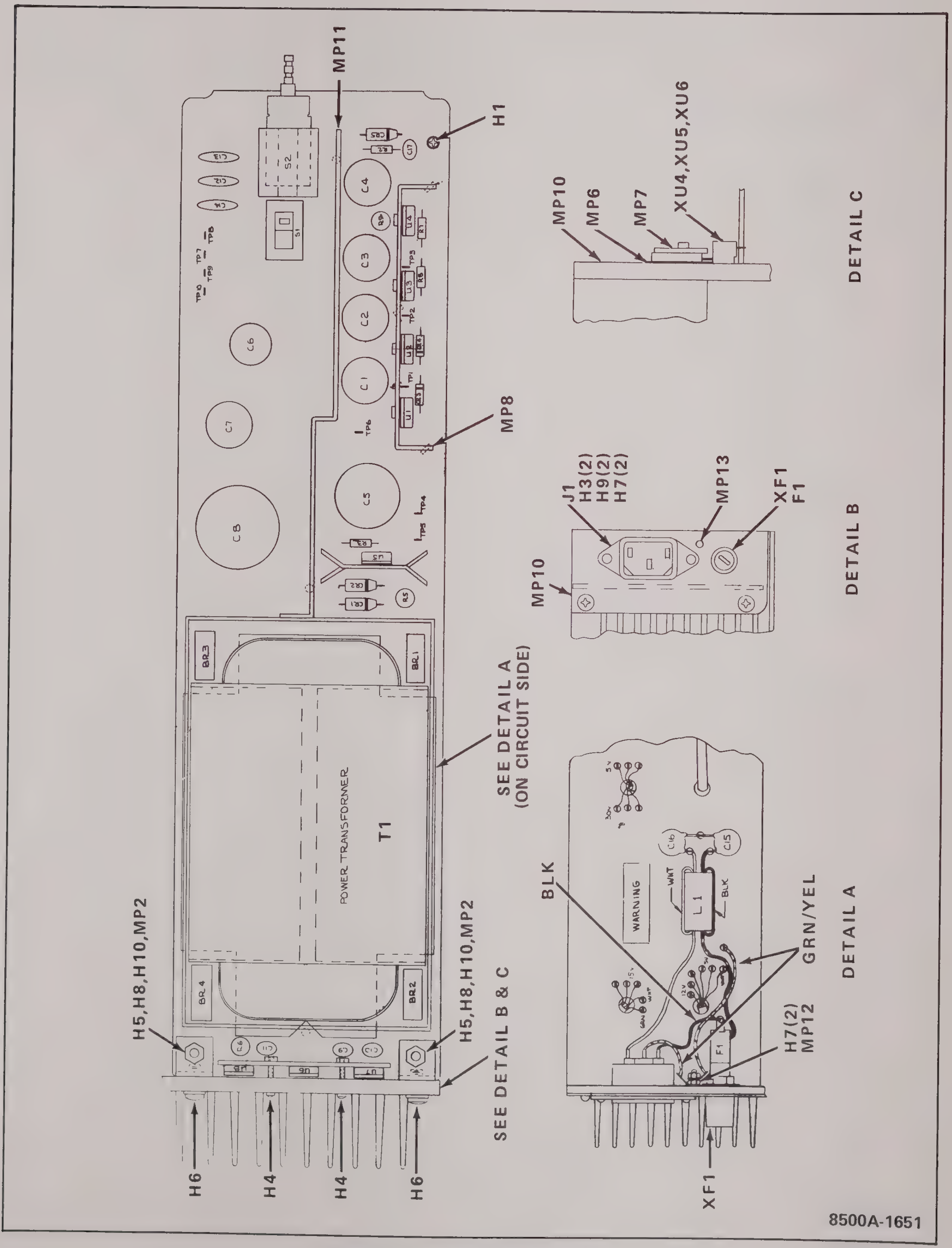

MP11
H1
MP8
MP10
MP6
MP7
XU4,XU5,XU6
DETAIL C
J1
H3(2)
H9(2)
H7(2)
MP13
XF1
F1
MP10
DETAIL B
SEE DETAIL A
(ON CIRCUIT SIDE)
POWER TRANSFORMER
T1
BR1
BR2
BR3
BR4
C1
C2
C3
C4
C5
C6
C7
C8
S1
S2
U1
U2
U3
U4
U5
U6
U7
U8
CR1
CR2
CR5
BLK
WARNING
WHT
L1
BLK
C15
C16
GRN/YEL
DETAIL A
H7(2)
MP12
F1
XF1
H5,H8,H10,MP2
H5,H8,H10,MP2
SEE DETAIL B & C
H6
H4
H4
H6
8500A-1651

Figure 5-5. A4 Power Supply Assembly

Table 5-6. A5 Power Supply Interconnect Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A5	POWER SUPPLY 8502A INTERCONNECT ASSY FIGURE 5-6 (8500A-4032)	401760	89536	401760	REF		
P1	CONNECTOR, BD EDGE, RECPT	291625	00779	583650-1	1		
P2	CONNECTOR, BD EDGE, RECPT	352682	00779	583694-2	1		

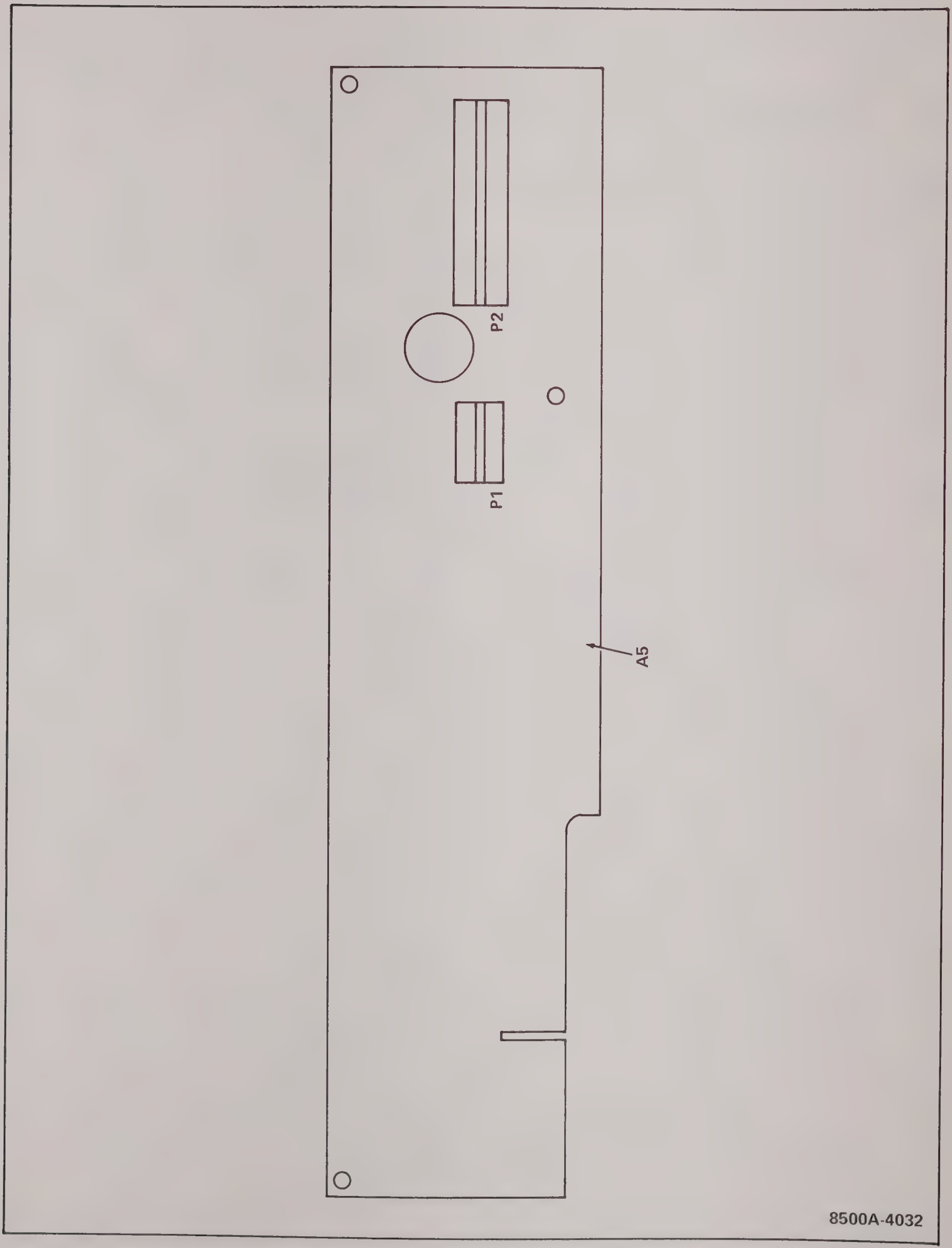

P2
P1
A5
8500A-4032

Figure 5-6. A5 Power Supply Interconnect Assembly

Table 5-7. A6 Controller Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A6	⊗CONTROLLER ASSEMBLY FIGURE 5-7 (8502A-4185T)	384024	89536	384024	REF		1
A6A1	CONTROLLER PCB ASSEMBLY (8502A-4185)	471318	89536	471318	1		
A6A2	PROM ROM PCB ASSEMBLY (8502A-4088T)	458141	89536	458141	1		
MP1	CASE, ASSY (INCLUDES MP2-MP9)	471326	89536	471326	1		2
MP2	CASE, HALF, MODULE	402990	89536	402990	REF		
MP3	CASE, HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE, CASE	486340	89536	486340	REF		
MP5	SHIELD, COVER	440008	89536	440008	REF		
MP6	DECAL, CONTROLLER	453696	89536	453696	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP10	MYLAR INSULATOR	463422	89536	463422	1		
U3	PROM 2716	490003	89536	490003	1		
U4	PROM 2716	489997	89536	489997	1		
U5	PROM 2716	489989	89536	489989	1		
U6	PROM 2716	489971	89536	489971	1		
U7	PROM 2716	489963	89536	489963	1		
U8	PROM 2716	489955	89536	489955	1		
U10	⊗IC, MOS, CPU	404541	01295	TMS8080	1	1	

1 EITHER OF THE A6 PCB ASSYS. MAY BE INSTALLLED IN THIS UNIT.

2 SEE TABLE 5-17 AT THE END OF SECTION 5.

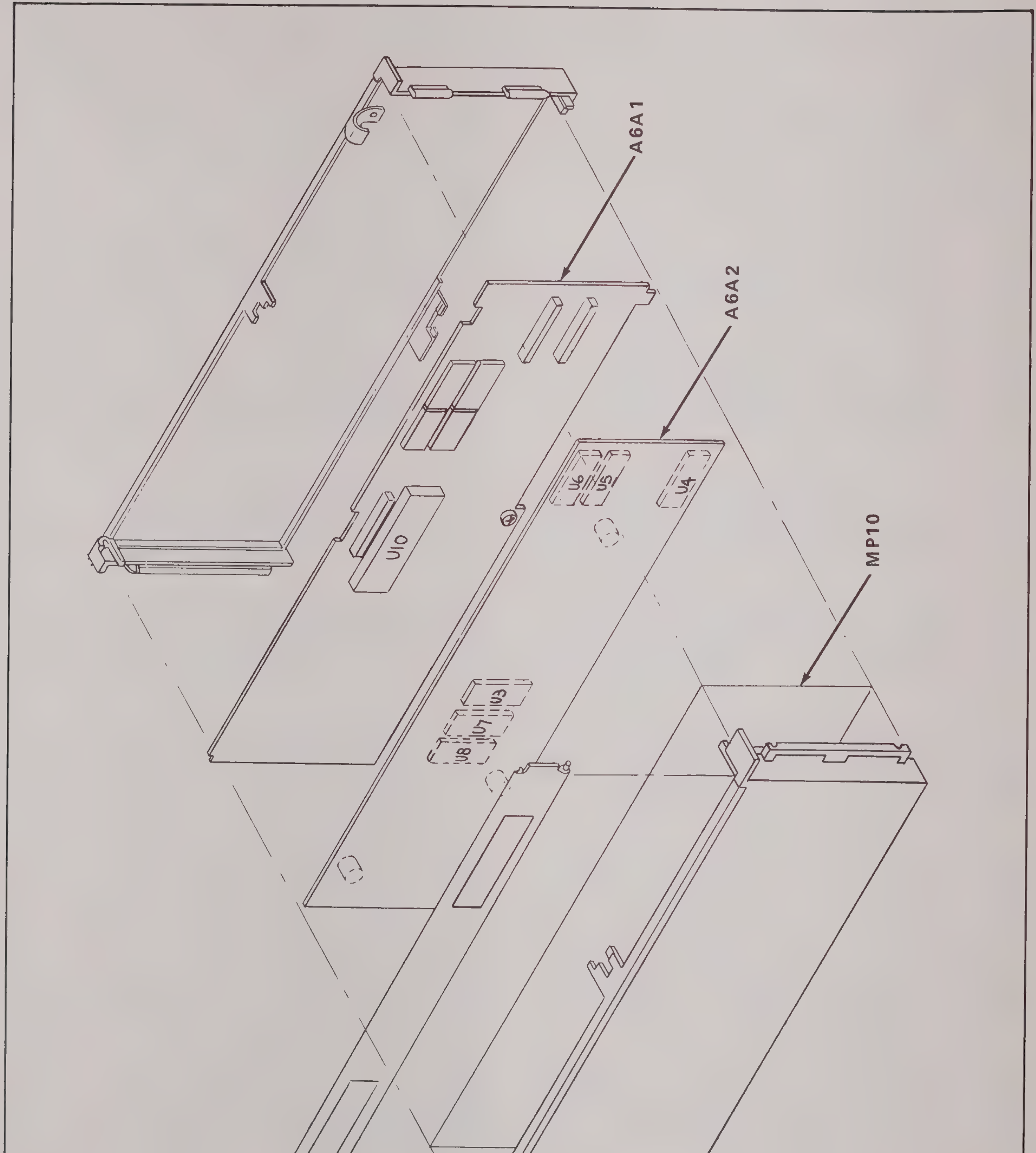

A6A1
A6A2
MP10
U10
U6
U5
U4
U3
U7
U8
8500A-4185

Figure 5-7. A6 Controller Assembly

Table 5-8. A6A1 Controller PCB Assembly

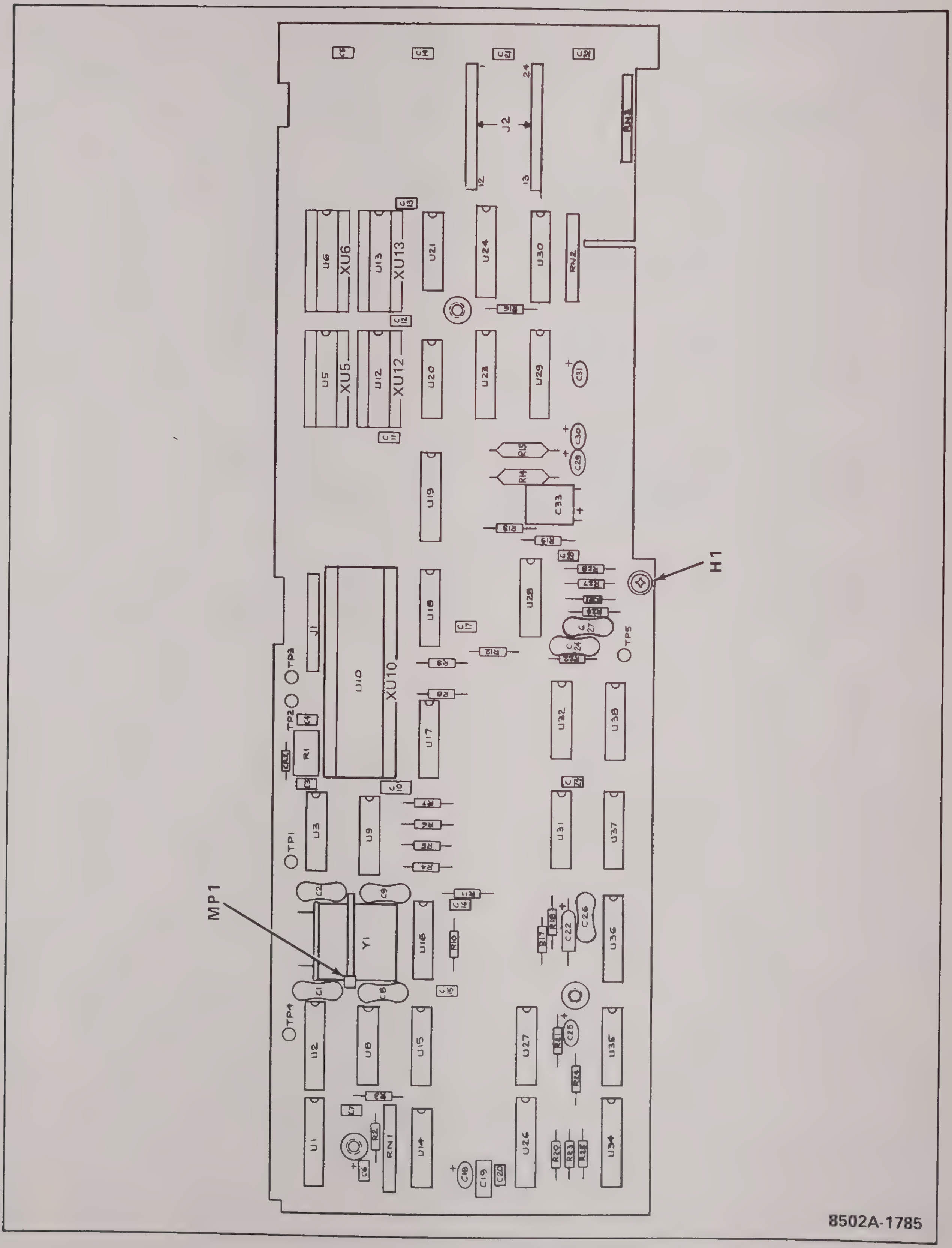
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A6A1	⊗CONTROLLER PCB ASSEMBLY FIGURE 5-8 (8502A-4185)	471318	89536	471318	REF		
C1	CAP, MICA, 22 PF +/-5%, 500V	148551	72136	DM15E220J	1		
C2	CAP, MICA, 47 PF +/-5%, 500V	148536	72136	DM15E470J	1		
C3	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	15		
C4	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C5	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C6	CAP, CER, 0.047 UF +/-20%, 50V	460733	71590	CW20C473M	1		
C7	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C8	CAP, MICA, 15 PF +/-5%, 500V	148569	72136	DM15C150J	1		
C9	CAP, MICA, 4 PF +/-0.5 PF, 500V	190397	72136	DM15C040E	1		
C10	CAP, CER, 1 UF +/-20%, 50V	436782	51642	300-050-601-105M	1		
C11	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C12	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C13	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C14	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C15	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C16	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C17	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C18	CAP, TA, 15 UF +/-20%, 6V	161935	56289	196D156X-0006-KA1	1		
C19	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	1		
C20	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C21	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C22	CAP, ELECT, TA, 1 UF +/-5%, 15V	461152	56289	150D106X-5015A2	1		
C23	CAP, CER, 10,000PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C24	CAP, MICA, 33 PF +/-5%, 500V	160317	72136	DM15E330J	2		
C25	CAP, TA, 39 UF +/-20%, 6V	163915	56289	196D396X-0006	1		
C26	CAP, CER, 220 PF +/-10%, 500V	268425	72982	851-000-Z5R-222K	1		
C27	CAP, MICA, 33 PF +/-5%, 500V	160317	72136	DM15E330J	REF		
C28	CAP, CER, 0.022 UF -20/+100%, 40V	358325	72982	8121-A050-651-223Z	1		
C29	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X-0020HA1	3		
C30	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X-0020HA1	REF		
C31	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X-0020HA1	REF		
C32	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C33	CAP, TA, 150 UF +/-20%, V6	460204	56289	183DR157X0006F	1		
CR1	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	2		
CR2	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
H1	SCREW, PHP, 4-40X3/8	256164	73734	23024	1		
J1	SOCKET, IC, 9-PIN	436774	30035	33-109-1-09	1		
J2	SOCKET, IC, 12-PIN	417733	30035	SS-109-1-12	2		
MP1	CLAMP, NYLON STRAP, TIE (NOT SHOWN)	172080	06383	SST1M	1		
MP2	DECAL, CONTROLLER (NOT SHOWN)	454108	89536	454108	1		
MP3	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	1		
R1	RES, VAR, CERMET, 10K +/-10%, 1/2W	285171	89536	285171	1		
R2	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	3		
R3	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	6		
R4	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	4		
R5	RES, DEP. CAR, 6.8K +/-5%, 1/4W	368761	80031	CR251-4-5P6K8	2		
R6	RES, COMP, 10M +/-5%, 1/4W	194944	01121	CB1065	1		

Table 5-8. A6A1 Controller PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R7	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	REF		
R8	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R9	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R10	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R11	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R12	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	3		
R13	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R14	RES, MTL. FILM, 715 +/-1%, 1/8W	313080	91637	CMF557150F	1		
R15	RES, MTL. FILM, 523 +/-0.5%, 1/8W	294835	91637	CMF555230F	1		
R16	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R17	RES, MTL. FILM, 4.99K +/-1%, 1/8W	168252	91637	CMF554991F	1		
R18	RES, MTL. FILM, 23.2K +/-1%, 1/8W	291351	91637	CMF552322F	1		
R19	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	REF		
R20	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R21	RES, DEP. CAR, 6.8K +/-5%, 1/4W	368761	80031	CR251-4-5P6K8	REF		
R22	RES, DEP. CAR, 3K +/-5%, 1/4W	441527	80031	CR251-4-5P3K	1		
R23	RES, DEP. CAR, 680K +/-5%, 1/4W	442517	80031	CR251-4-5P680K	1		
R24	RES, DEP. CAR, 1.5K +/-5%, 1/4W	343418	80031	CR251-4-5P1K5	1		
R25	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R26	RES, DEP. CAR, 62K +/-5%, 1/4W	348904	80031	CR251-4-5P62K	1		
R27	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	REF		
R28	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
RN1	RESISTOR NETWORK, 4.7K	412916	89536	412916	2	1	
RN2	RESISTOR NETWORK, 4.7K	412916	89536	412916	REF		
RN3	RESISTOR NETWORK, 10K	412924	89536	412924	1	1	
U1	IC, TTL, LPS, DUAL J-K FF	412999	01295	SN74LS109N	1	1	
U2	⊗IC, C-MOS, HEX BUFFER/INVERTERS	381830	02735	CD4050AE	1	1	
U3	⊗IC, C-MOS, FAST QUAD 2-INPUT NAND GATE	413211	07263	34011PC4011PC	1	1	
U5	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111A-4	4	1	
U6	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111-1	REF		
U8	IC, TTL, AND-OR INVERT GATES	412981	01295	SN74LS51	1	1	
U9	⊗IC, C-MOS, HEX INVERTER	404699	12040	MM74C04N	1	1	
U12	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111-1	REF		
U13	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111-1	REF		
U14	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	04713	MC14013CP	2	1	
U15	IC, TTL, QUAD 2-INPUT POS AND GATES	393066	01295	SN74LS08	1	1	
U16	IC, TTL, HEX INVERTER POS NAND GATES	393058	01295	SN74LS04	2	1	
U17	⊗IC, C-MOS, QUAD 2-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U18	IC, TTL, HEX/QUAD TYPE D FLIP FLOP	393207	01295	SN74LS174N	1	1	
U19	⊗IC, C-MOS STROBED HEX INVERTER/BUFFER	408211	04713	MC14502CP	2	1	
U20	IC, TTL, MULTIPLEXER	393165	01295	SN74LS139N	1	1	
U21	IC, TTL, HEX INVERTER POS NAND GATES	393058	01295	SN74LS04	REF		
U23	⊗IC, C-MOS TRISTATE NON INVERT BUFFERS	407759	12040	MM80C97N	3	1	
U24	⊗IC, C-MOS TRISTATE NON INVERT BUFFERS	407759	12040	MM80C97N	REF		
U26	IC, LIN, C-MOS, PLL	403584	02735	CD4046AE	1	1	
U27	⊗IC, C-MOS, QUAD 2-INPUT OR GATE	408393	02735	CD4071BE	1	1	
U28	⊗IC, C-MOS, 8-BIT PRIORITY ENCODER	412973	02735	CD4523BE	1	1	
U29	⊗IC, C-MOS, STROBED HEX INVERTER/BUFFER	408211	04713	MC14502CP	REF		
U30	⊗IC, C-MOS, TRISTATE NON INVERT BUFFERS	407759	12040	MM80C97N	REF		
U31	IC, TTL, POS NAND GATES/INVERTERS	393074	01295	SN74LS10N	1	1	

Table 5-8. A6A1 Controller PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
U32	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	1	1	
U34	⊗IC, C-MOS, DUAL UP COUNTER	355164	04713	MC14520CL/CP	1	1	
U35	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	04713	MC14013CP	REF		
U36	⊗IC, C-MOS, NONOSTABLE MV	454017	04713	MC14538BCP	1	1	
U37	⊗IC, C-MOS, QUAD 2-INPUT NOR GATES	429944	02735	CD4001BE	1	1	
U38	⊗IC, C-MOS, QUAD 2-INPUT NAND	404632	02735	CD4039BE	1	1	
XU5	SOCKET, IC, 18-PIN	418228	91506	318-AG39D	4		
XU6	SOCKET, IC, 18-PIN	418228	91506	318-AG39D	REF		
XU10	SOCKET, IC, 40-PIN	418988	91506	340-AG39D	1		
XU12	SOCKET, IC, 18-PIN	418228	91506	318-AG39D	REF		
XU13	SOCKET, IC, 18-PIN	418228	91506	318-AG39D	REF		
Y1	CRYSTAL, QUARTZ	412932	89536	412932	1		


MP1
H1
J2
1
24
12
13
RN1
RN2
RN3
XU5
XU6
XU10
XU12
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U1
U2
U3
U5
U6
U8
U9
U10
U12
U13
U14
U15
U16
U17
U18
U19
U20
U21
U23
U24
U26
U27
U28
U29
U30
U31
U32
U34
U35
U36
U37
U38
Y1
J1
R1
R2
R4
R5
R6
R7
R8
R9
R10
R12
R14
R15
R16
R17
R18
R19
C1
C2
C6
C8
C9
C10
C11
C12
C13
C15
C16
C17
C19
C20
C22
C24
C25
C26
C27
C29
C30
C31
C33
TP1
TP2
TP3
TP4
TP5
8502A-1785

Figure 5-8. A6A1 Controller PCB Assembly

Table 5-9. A6A2 Prom Rom PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A6A2	⊗PROM ROM PCB ASSEMBLY FIGURE 5-9 (8502A-4088T)	458141	89536	458141	REF		
C1	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	1		
C3	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	6		
C4	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C5	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C6	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C7	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C8	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C17	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	1		
H1	WASHER, FLAT, TEFLON (NOT SHOWN)	187989	89536	187989	6		
MP1	INSERTS, BOARD (NOT SHOWN)	376418	89536	376418	72		
P1	POST, CONTACT	447813	22526	65501-136	1		
P2	POST, CONTACT	447813	22526	65501-136	2		
R1	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
U1	IC, TTL, SCHOTTKY 3-8 LINE DECODER	407585	01295	SN74LS138N	1		
U17	⊗IC, C-MOS TRISTATE HEX NON INV BUFFER	407759	04713	MC14503CP	3		
U18	⊗IC, C-MOS TRISTATE HEX NON INV BUFFER	407759	04713	MC14503CP	REF		
U19	⊗IC, C-MOS TRISTATE HEX NON INV BUFFER	407759	04713	MC14503CP	REF		
U20	IC, TTL, POS AND GATES	393066	01295	SN74LS08N	1		
U21	IC, TTL, QUAD, 2-INPUT POS OR GATE	393108	01295	SN74LS32N	1	1	
XU4	SOCKET, 24 PIN	376236	91506	324-AG39D	3		
XU5	SOCKET, 24 PIN	376236	91506	324-AG39D	REF		
XU6	SOCKET, 24 PIN	376236	91506	324-AG39D	REF		

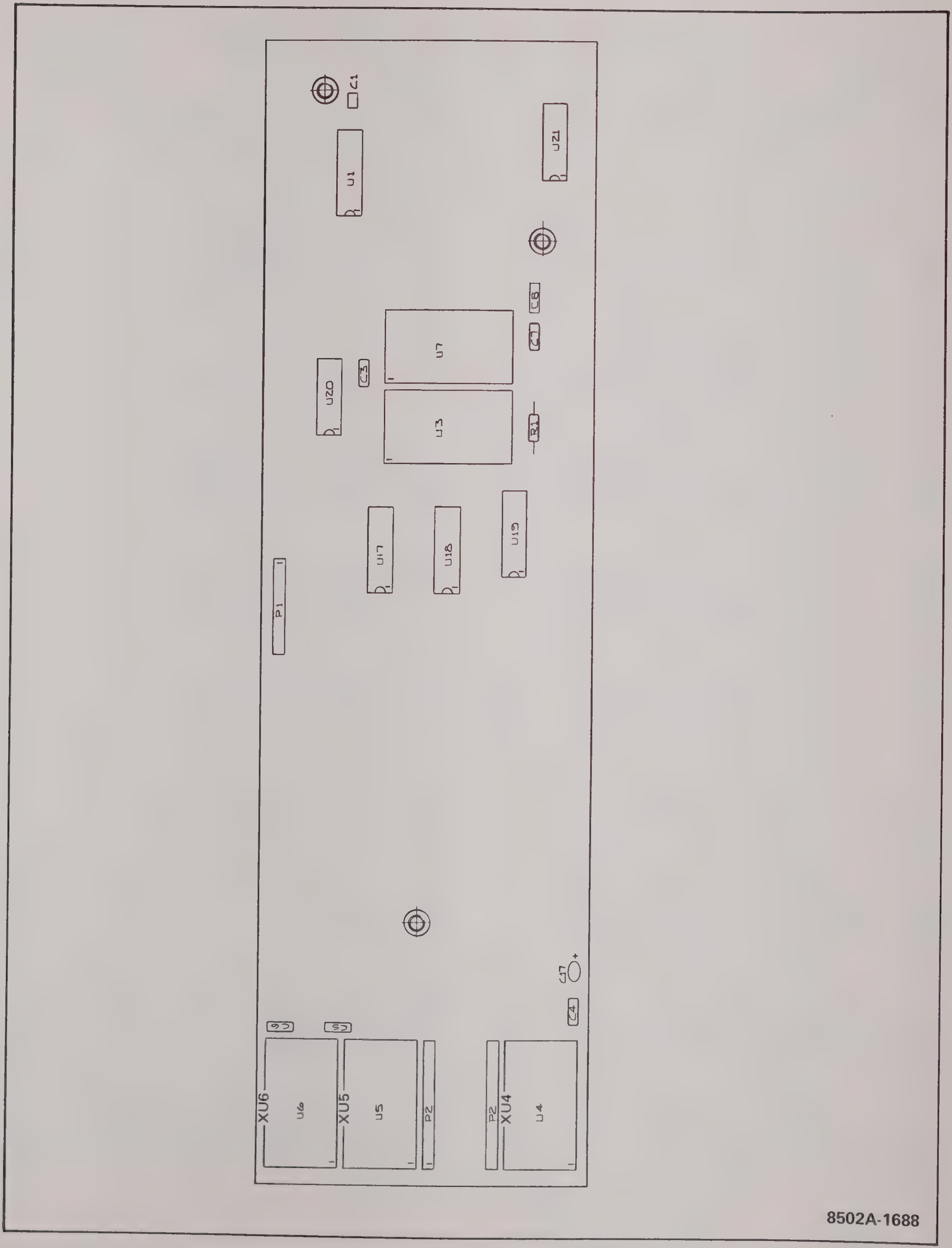

C1
U1
U21
C8
C7
U7
C3
U20
U3
R1
U17
U18
U19
P1
C17
+
C4
C6
C5
XU6
U6
XU5
U5
P2
P2
XU4
U4
8502A-1688

Figure 5-9. A6A2 Prom Rom PCB Assembly

Table 5-10. A6 Controller PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A6	⊗CONTROLLER PCB ASSEMBLY FIGURE 5-10 (8502A-4186T)	577072	89536	577072	REF		1
C1	CAP, MICA, 22 PF +/-5%, 500V	148551	02799	DM15C220J	1		
C2	CAP, MICA, 47 PF +/-5%, 500V	148536	02799	DM15E470J	1		
C3	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	15		
C4	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C5	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C6	CAP, CER, 0.047 UF +/-20%, 50V	460733	72982	8121-050-651-47NM	1		
C7	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C8	CAP, MICA, 15 PF +/-5%, 500V	148569	02799	DM15C150J	1		
C9	CAP, MICA, 4 PF +/-0.5%, 500V	190397	02799	DM15C040D	1		
C10	CAP, CER, 1 UF +/-20%, 50V	436782	72982	8131-050-601-105M	1		
C11	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C12	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C13	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C14	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C15	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C16	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C17	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C18	CAP, TA, 15 UF +/-20%, 6V	161935	56289	196D156X0006-KA1	1		
C19	CAP, CER, 0.22 UF +/-20%, 50V	309849	72982	8131-050-651-222M	1		
C20	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C21	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C22	CAP, ELECT, TA, 1 UF +/-5%, 15V	461152	56289	150D106X5015A2	1		
C23	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C24	CAP, MICA, 33 PF +/-5%, 500V	160317	02799	DM15E330J	2		
C25	CAP, TA, 39 UF +/-20%, 6V	163915	56289	196D396X0006	1		
C26	CAP, CER, 2200 PF +/-10%, 500V	268425	72982	851-000-Z5R-222K	1		
C27	CAP, MICA, 33 PF +/-5%, 500V	160317	02799	DM15E330J	REF		
C28	CAP, CER, 0.022 UF -20/+100%, 40V	358325	72982	8121-A050-651-223Z	1		
C29	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	3		
C30	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	REF		
C31	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	REF		
C32	CAP, CER, 10,000 PF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C33	CAP, TA, 150 UF +/-20%, 6V	460204	56289	183DR157X0006F	1		
CR1	DIODE, SI, HI SPEED SWITCHING	203323	07910	1N4448	2	1	
CR2	DIODE, SI, HI SPEED SWITCHING	203323	07910	1N4448	REF		
H1	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		
MP1	CASE ASSY (INCLUDES MP2-MP9)	611665	89536	611665	1		2
MP2	CASE, HALF, MODULE	402990	89536	402990	REF		
MP3	CASE, HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE, CASE	402974	89536	402974	REF		
MP5	SHIELD COVER	440008	89536	440008	REF		
MP6	DECAL, CONTROLLER (NOT SHOWN)	536029	89536	536029	REF		
MP7	DECAL, CAUTION (NOT SHOWN)	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP10	CLAMP, NYLON STRAP	172080	06383	SSTIM	1		
MP11	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380M	1		

Table 5-10. A6 Controller PCB Assembly (cont)

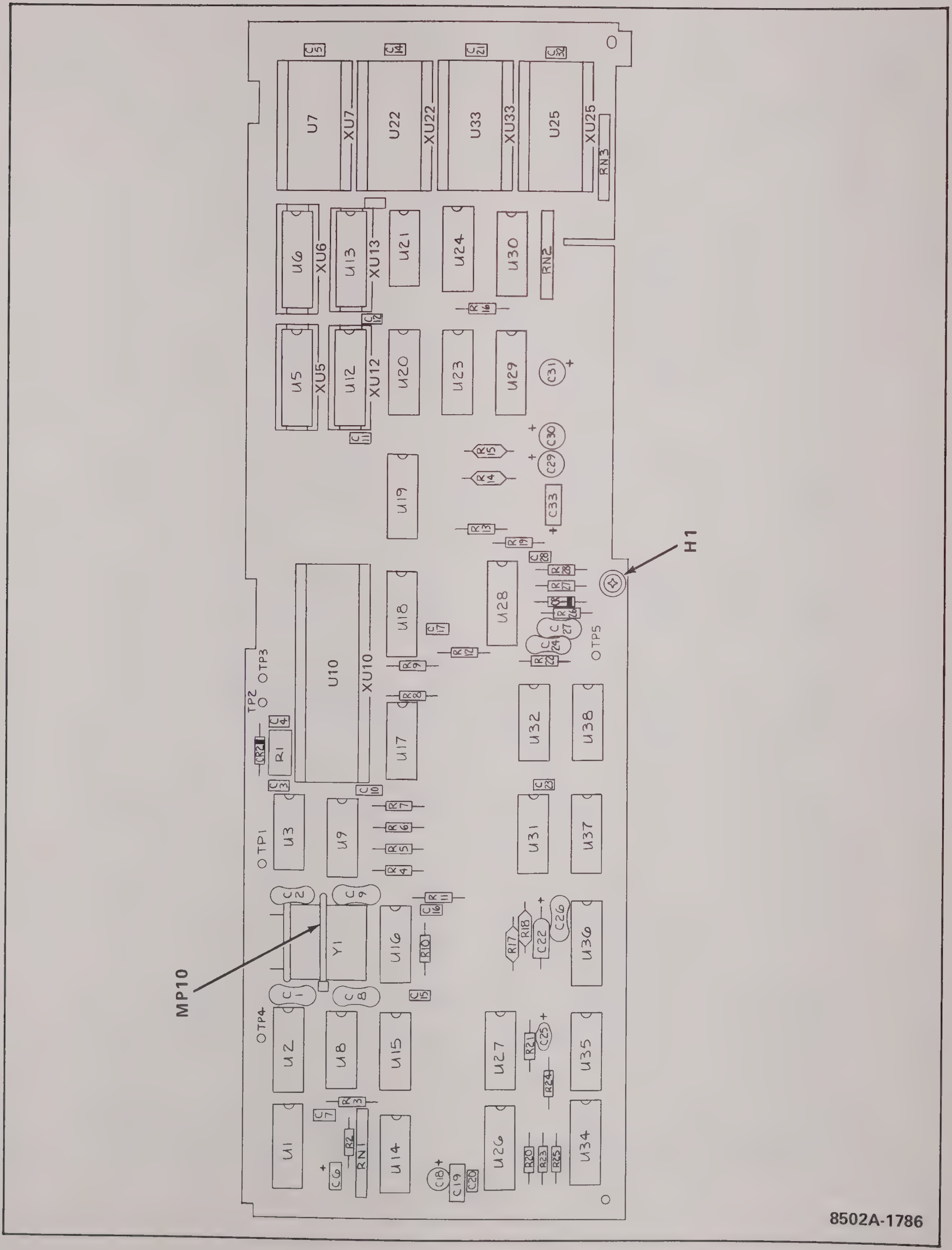
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP12	MYLAR INSULATOR	463422	89536	463422	1		
R1	RES, VAR, CERMET, 10K +/-10%, 1/2W	285171	89536	285171	1		
R2	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	3		
R3	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	6		
R4	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	4		
R5	RES, DEP. CAR, 6.8K +/-5%, 1/4W	368761	80031	CR251-4-5P6K8	2		
R6	RES, COMP, 10M +/-5%, 1/4W	194944	01121	CB1065	1		
R7	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	REF		
R8	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R9	RES, DEP. CAR, 4.7K +/-5% 1/4W	348821	80031	CR251-4-5P4K7	REF		
R10	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R11	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R12	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	3		
R13	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R14	RES, MTL. FILM, 715 +/-1%, 1/8W	313080	91637	CMF557150F	1		
R15	RES, MTL. FILM, 523 +/-1%, 1/8W	294835	91637	CMF555230D	1		
R16	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R17	RES, MTL. FILM, 4.99K +/-1%, 1/8W	168252	91637	CMF554991F	1		
R18	RES, MTL. FILM, 23.2K +/-1%, 1/8W	291351	91637	CMF552322F	1		
R19	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	REF		
R20	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R21	RES, DEP. CAR, 6.8K +/-5%, 1/4W	368761	80031	CR251-4-5P6K8	REF		
R22	RES, DEP. CAR, 3K +/-5%, 1/4W	441527	80031	CR251-4-5P3K	1		
R23	RES, DEP. CAR, 680K +/-5%, 1/4W	442517	80031	CR251-4-5P680K	1		
R24	RES, DEP. CAR, 1.5K +/-5%, 1/4W	343418	80031	CR251-4-5P1K5	1		
R25	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R26	RES, DEP. CAR, 30K +/-5%, 1/4W	368753	80031	CR251-4-5P30K	1		
R27	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	REF		
R28	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
RN1	RES NETWORK, SIP, 4.7K	412916	89536	412916	2	1	
RN2	RES NETWORK, SIP, 4.7K	412916	89536	412916	REF		
RN3	RES NETWORK, SIP, 10K	412924	89536	412924	1	1	
U1	IC, TTL LPS, DUAL J-K FF	412999	01295	SN74LS109N	1	1	
U2	⊗IC, C-MOS, HEX BUFFER/INVERTERS	381830	02735	CD4040BCN	1	1	
U3	⊗IC, C-MOS, FAST QUAD 2 INPUT NAND GATE	413211	07263	34011PC/4011PC	1	1	
U5	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111A-4	4	1	
U6	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111A-4	REF		
U7	PROM	613505	89536	613505	1		
U8	IC, TTL-AND-OR-INVERT GATES	412981	01295	SN74LS51	1	1	
U9	⊗IC, C-MOS, HEX INVERTER	404699	12040	MM74C04N	1	1	
U10	⊗IC, MOS, CPU	404541	01295	TMS8080	1	1	
U12	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111A-4	REF		
U13	⊗IC, MOS 1024 BIT STATIC RAM	404558	34649	P2111A-4	REF		
U14	⊗IC, C-MOS, DUAL TYPE "D" FLIP FLOP	340117	04713	MC14013CP	2	1	
U15	IC, TTL QUAD 2 INPUT POS AND GATES	393066	01295	SN74LS08N	1	1	
U16	IC, TTL HEX INVERTER POS NAND GATES	393058	01295	SN74LS04N	2	1	
U17	⊗IC, C-MOS TRI 3 INPUT NAND GATES	375147	02735	CD4023UBE	1	1	
U18	IC, TTL HEX/QUAD TYPE D FLIP FLOP	393207	01295	SN74LS174N	1	1	
U19	⊗IC, C-MOS STROBED HEX INVERTER/BUFFER	408211	04713	MC14502CP	2	1	
U20	IC, TTL MULTIPLEXER	393165	01295	SN74LS139N	1	1	

Table 5-10. A6 Controller PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
U21	IC, TTL HEX INVERTER POS NAND GATES	393058	01295	SN74LS04	REF		
U22	ROM	604132	89536	604132	1		
U23	⊗IC, C-MOS TRISTATE NON INVERT BUFFERS	407759	12040	MM80C97N	3	1	
U24	⊗IC, C-MOS TRISTATE NON INVERT BUFFERS	407759	12040	MM80C97N	REF		
U25	ROM	604116	89536	604116	1		
U26	IC, LIN C-MOS/MOS PLL	403584	02735	CD4046AE	1	1	
U27	⊗IC, C-MOS, QUAD 2 INPUT OR GATE	408393	02735	CD4071BE	1	1	
U28	⊗IC, C-MOS 8-BIT PRIORITY ENCODER	412973	02735	CD4523BE	1	1	
U29	⊗IC, C-MOS STROBED HEX INVERTER/BUFFER	408211	04713	MC14502CP	REF		
U30	⊗IC, C-MOS TRISTATE NON INVERT BUFFERS	407759	12040	MM80C97N	REF		
U31	IC, TTL POS NAND GATES/INVERTERS	393074	01295	SN74LS10N	1	1	
U32	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069UBE	1	1	
U33	ROM	604124	89536	604124	1		
U34	⊗IC, C-MOS DUAL UP COUNTER	355164	04713	MC14520BCP	1	1	
U35	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	04713	MC14013CP	REF		
U36	⊗IC, C-MOS, MONOSTABLE MV	454017	04713	MC14538BCP	1	1	
U37	⊗IC, C-MOS QUAD 2 INPUT NOR GATES	429944	02735	CD4001BE	1	1	
U38	⊗IC, C-MOS QUAD 2 INPUT NAND	404632	02735	CD4093BE	1	1	
XU5	SOCKET, IC, 18-PINS	418228	91506	318-AG39D	4		
XU6	SOCKET, IC, 18-PINS	418228	91506	318-AG39D	REF		
XU7	SOCKET, IC, 24-PINS	376236	91506	324-AG39D	4		
XU10	SOCKET, IC, 40-PINS	418988	91506	340-AG39D	1		
XU12	SOCKET, IC, 18-PINS	418228	91506	318-AG39D	REF		
XU13	SOCKET, IC, 18-PINS	418228	91506	318-AG39D	REF		
XU22	SOCKET, IC, 24-PINS	376236	91506	324-AG39D	REF		
XU25	SOCKET, IC, 24-PINS	376236	91506	324-AG39D	REF		
XU33	SOCKET, IC, 24-PINS	376236	91506	324-AG39D	REF		
Y1	CRYSTAL, QUARTZ, 1.70 MHZ	412932	89536	412932	1		

1 EITHER OF THE A6 PCB ASSYS. MAY BE INSTALLED IN THIS UNIT.

2 SEE TABLE 5-17 AT THE END OF SECTION 5.


MP10
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Y1
RN1
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CR2
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8502A-1786

Figure 5-10. A6 Controller PCB Assembly

Table 5-11. A7 Display PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A7	⊗DISPLAY PCB ASSEMBLY FIGURE 5-11 (8502A-4023T)	481689	89536	481689	REF		
C1	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	1		
C2	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	1		
C3	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	1		
CR1	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	6	2	
CR2	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR5	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR6	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR7	DIODE, LED	413831	29083	MV5153	1	1	
E1	SPARK GAP (NOT SHOWN)	442731	25088	B1C145	1		
F1	FUSE, FAST-BLO	109330	71400	AGC11-2	1	5	
F2	FUSE, WIRE #36	160978	89536	160978	1		
J1	BINDING POST, RED	275552	32767	820-65	2		
J2	BINDING POST, RED	275552	32767	820-65	REF		
J3	BINDING POST, BLK	275560	32767	820-45	2		
J4	BINDING POST, BLK	275560	32767	820-45	REF		
J5	BINDING POST, BLUE	275578	32767	820-55	1		
L1	COIL ASSEMBLY	438325	89536	438325	1		
MP1	INSULATING BINDING POST (NOT SHOWN)	449363	89536	449363	1		
MP2	MASK, 0.40 LENS (NOT SHOWN)	418996	89536	418996	4		
MP3	SHIELD, FRONT PANEL (NOT SHOWN)	433524	89536	433524	1		
MP4	SPACER (NOT SHOWN)	448432	89536	448432	1		
P1	CONNECTOR PIN	233411	00779	60599-3	5		
Q1	TRANSISTOR, SI, NPN	330803	04713	MPS6560	1	1	
Q2	TRANSISTOR, SI, PNP	340026	04713	MPS6563	7	2	
Q3	TRANSISTOR, SI, PNP	340026	04713	MPS6563	REF		
Q4	TRANSISTOR, SI, PNP	340026	04713	MPS6563	REF		
Q5	TRANSISTOR, SI, PNP	340026	04713	MPS6563	REF		
Q6	TRANSISTOR, SI, PNP	340026	04713	MPS6563	REF		
Q7	TRANSISTOR, SI, PNP	340026	04713	MPS6563	REF		
Q8	TRANSISTOR, SI, PNP	340026	04713	MPS6563	REF		
Q10	TRANSISTOR, SI, PNP	226290	04713	MPS3640	1	1	
R1	RES, DEP. CAR, 62 +/-5%, 1/4W	441634	80031	CR251-4-SP62ET	1		
R2	RES, DEP. CAR, 200 +/-5%, 1/4W	441451	80031	CR251-4-5P200ET	2		
R3	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100KT	1		
R4	RES, COMP, 150 +/-5%. 1/4W	343442	80031	CR251-4-5P150ET	1		
R5	RES, COMP, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7T	1		
R6	RES, COMP, 200 +/-5%, 1/4W	441451	80031	CR251-4-5P200ET	REF		
R7	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E			
R8	RES, COMP, 10M +/-5%, 1/4W	194944	01121	CB1065	1		
S1	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	23		
	SWITCH TOP COVER	401299	89536	401299	23		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	23		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	23		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	14		

Table 5-11. A7 Display PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
S2	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S3	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S4	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S5	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S6	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, DK PUTTY GREY	406728	89536	406728	6		
S7	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, DK PUTTY GREY	406728	89536	406728	REF		
S8	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, DK PUTTY GREY	406728	89536	406728	REF		
S9	SWITCH, SLIDE, SPDT	417287	95146	MSS-104D-1	1		
S10	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, MED YELLOW	419937	89536	419937	2		
S11	SWITCH ASSEMBLY						

Table 5-11. A7 Display PCB Assembly (cont)

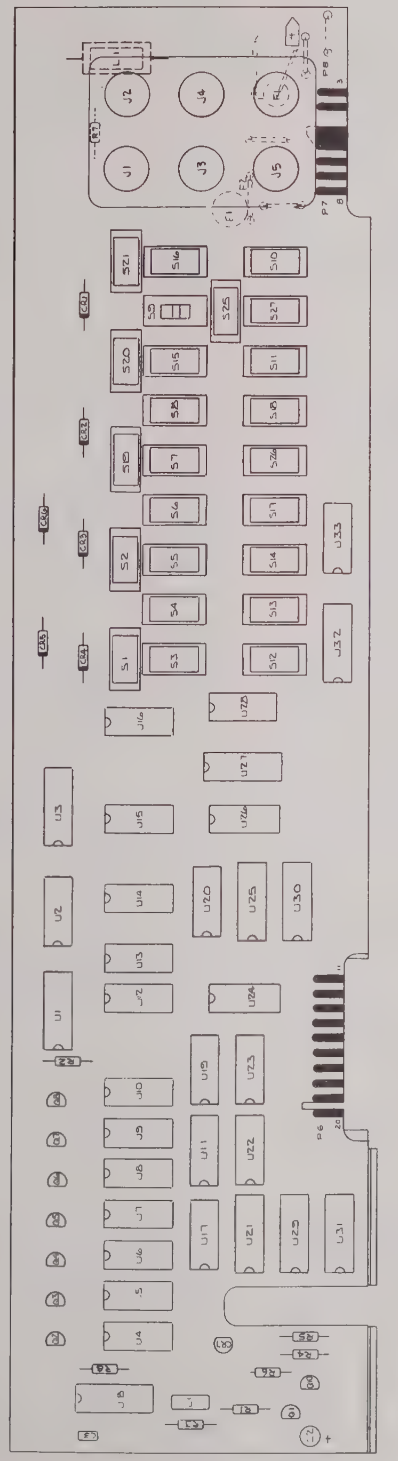
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, MED YELLOW	419937	89536	419937	REF		
S12	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, DK PUTTY GREY	406728	89536	406728	REF		
S13	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, DK PUTTY GREY	406728	89536	406728	REF		
S14	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, DK PUTTY GREY	406728	89536	406728	REF		
S15	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S16	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S17	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S18	SWITCH ASSEMBLY						
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, BLUE	406736	89536	406736	1		
S19	SWITCH ASSEMBLY				REF		
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		

Table 5-11. A7 Display PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S20	SWITCH ASSEMBLY				REF		
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S21	SWITCH ASSEMBLY				REF		
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S25	SWITCH ASSEMBLY				REF		
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S26	SWITCH ASSEMBLY				REF		
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
S27	SWITCH ASSEMBLY				REF		
	SWITCH ACTUATOR	412106	89536	412106	REF		
	SWITCH TOP COVER	401299	89536	401299	REF		
	SPRING, SWITCH, PUSHBUTTON	414516	00779	62353-3	REF		
	CONTACT, SWITCH, PUSHBUTTON	416875	00779	62380-4	REF		
	SWITCH, PUSHBUTTON, LT PUTTY GREY	401307	89536	401307	REF		
U1	IC, LIN, NPN, TRANSISTOR ARRAY	407866	02735	CA3081	3	1	
U2	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	1	1	
U3	⊗IC, C-MOS, HEX D FLIP FLOP	404509	12040	MM74C174N	3	1	
U4	DISPLAY, LED	453282	29083	MAN4630A	2	1	
U5	DISPLAY SET	440016	89536	440016	1	1	
U6	DISPLAY SET	440016	89536	440016	REF		
U7	DISPLAY SET	440016	89536	440016	REF		
U8	DISPLAY SET	440016	89536	440016	REF		
U9	DISPLAY SET	440016	89536	440016	REF		
U10	DISPLAY SET	440016	89536	440016	REF		
U11	⊗IC, C-MOS, QUAD, 2-INPUT NAND GATE	355198	02735	CD4011AE	1	1	
U12	DISPLAY, LED	453282	29083	MAN4630A	REF		
U13	DISPLAY SET	440016	89536	440016	REF		
U14	DISPLAY, LED	453274	29083	MAN4610A	4	1	
U15	DISPLAY, LED	453274	29083	MAN4610A	REF		
U16	⊗IC, C-MOS, DUAL, FLIP FLOP	340117	04713	MC14013CL	3	1	
U17	RES NETWORK 4.7K	344069	89536	344069	2	1	

Table 5-11. A7 Display PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
U18	⊗IC, C-MOS, RETRIGGERABLE/RESETTABLE	393512	04713	MC14528CP	1	1	
U19	⊗IC, C-MOS, DUAL 4-INPUT NAND GATE	355206	04713	MC14012CP	1	1	
U20	RES NETWORK 4.7K	344069	89536	344069	REF		
U21	IC, LIN, NPN, TRANSISTOR ARRAY	407866	02735	CA3081	REF		
U22	⊗IC, C-MOS, DUAL, FLIP FLOP	340117	04713	MC14013CL	REF		
U23	⊗IC, C-MOS, DUAL, FLIP FLOP	340117	04713	MC14013CL	REF		
U24	DISPLAY, LED	453274	29083	MAN4610A	REF		
U25	IC, LIN, NPN, TRANSISTOR ARRAY	407866	02735	CA3081	REF		
U26	DISPLAY, LED	453274	29083	MAN4610A	REF		
U27	⊗IC, C-MOS, HEX D FLIP FLOP	404509	12040	MM74C174N	REF		
U28	⊗IC, C-MOS, TRIPLE 3-INPUT NAND GATE	375147	04713	MC14023CP	1	1	
U29	RES, DUAL, IN LINE PACKAGE	358119	89536	358119	2	1	
U30	RES, DUAL, IN LINE PACKAGE	358119	89536	358119	REF		
U31	⊗IC, C-MOS, HEX D FLIP FLOP	404509	12040	MM74C174N	REF		
U32	⊗IC, C-MOS TRI STATE HEX NON INVRT BUFFER	407759	12040	MM80C97N	1	1	
U33	RESISTOR NETWORK, 4.7K	386961	89536	386961	1	1	
XF1	FUSEHOLDER ASSY (NOT SHOWN)				1		
	FUSEHOLDER	435628	89536	435628			
	CAP, WHITE	455857	89536	455857			
XU4	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	13		
XU5	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU6	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU7	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU8	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU9	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU10	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU12	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU13	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU14	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU15	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU24	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		
XU26	SOCKET, IC (NOT SHOWN)	453514	71785	133-59-90-0901/14E	REF		


J1
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8502A-1623

Figure 5-11. A7 Display PCB Assembly

Table 5-12. A8 DC Signal Conditioner PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A8	⊗DC SIGNAL CONDITIONER PCB ASSEMBLY FIGURE 5-12 (MIS-4100T)	383901	89536	383901	REF		
C1	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	2		
C2	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C3	CAP, CER, 0.22 UF +/-20%, 50V	309849	72982	8131-050-651-220NM	2		
C4	CAP, CER, 0.22 UF +/-20%, 50V	309849	72982	8131-050-651-220NM	REF		
C5	CAP, TA, 30 UF +/-20%, 6V	163915	56289	196D396X0006	1		
C10	CAP, ELECT, 6.8 UF -10/+50%, 63V	218966	80031	ET6P8X063A3	2	1	
C11	CAP, ELECT, 6.8 UF -10/+50%, 63V	218966	80031	ET6P8X063A3	REF		
C12	CAP, MICA, 100 PF +/-5%, 500V	148494	02799	DM15F101J	2		
C13	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	1		
C14	CAP, MICA, 100 PF +/-5%, 500V	148494	02799	DM15F101J	REF		
C15	CAP, MICA, 47 PF +/-5%, 500V	148536	02799	DM15E470J	2		
C16	CAP, MICA, 47 PF +/-5%, 500V	148536	02799	DM15E470J	REF		
C18	CAP, CER, 33 PF +/-2%, 100V	354852	80031	2222-638-10339	2		
C19	CAP, CER, 33 PF +/-2%, 100V	354852	80031	2222-638-10339	REF		
CR1	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	2	1	
CR2	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, ZENER	181073	07910	1N969B	2	1	
CR4	DIODE, ZENER	181073	07910	1N969B	REF		
CR5	DIODE, SI, LOW-CAP, LOW LEAKAGE	348177	07263	FD7223	1	1	
H1	SCREW, RHP, 4-40 X 3/8	256164	89536	256164	1		
K1	RELAY, ARMATURE	515437	89536	515437	2		
K2	RELAY, ARMATURE	515437	89536	515437	REF		
MP1	CASE ASSY (INCLUDES MP2-MP9)	458992	89536	458992	1		1
MP2	CASE HALF	402990	89536	402990	REF		
MP3	CASE HALF	402990	89536	402990	REF		
MP4	COVER, CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411918	89536	411918	REF		
MP6	DECAL, DC SIGNAL CONDITIONER ASSY	413377	89536	413377	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP11	TERMINAL, FEED-THROUGH (NOT SHOWN)	281865	12615	SL-841-777	1		
MP12	SOCKET, SPRING TYPE (NOT SHOWN)	343285	00779	2-331272-6	8		
MP13	SPACER (NOT SHOWN)	334797	32559	TO-35-15-E	1		
MP14	SPACER, TRANSIPAD (NOT SHOWN, USE W/Q37)	152207	07047	10123-DAP	1		
MP15	SPRING, COIL (NOT SHOWN)	424465	27745	C0120-014-0380M	1		
Q1	TRANSISTOR, NPN, SI	330803	07263	MPS6560	2	1	
Q2	TRANSISTOR, PNP, SI	195974	04713	2N3906	6	2	
Q3	TRANSISTOR, NPN, SI	330803	07263	MPS6560	REF		
Q4	TRANSISTOR, PNP, SI	195974	04713	2N3906	REF		
Q5	TRANSISTOR, PNP, SI	226290	04713	MPS3640	1	1	
Q6	TRANSISTOR, PNP, SI	195974	04713	2N3906	REF		
Q7	TRANSISTOR, NPN, SI	218396	04713	2N3904	11	3	
Q8	TRANSISTOR, FET,. N-CHANNEL	393314	89536	393314	4	1	
Q10	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q11	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q12	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		

Table 5-12. A8 DC Signal Conditioner PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q13	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q14	TRANSISTOR, FET,. N-CHANNEL	393314	89536	393314	REF		
Q15	TRANSISTOR, FET,. N-CHANNEL	393314	89536	393314	REF		
Q16	TRANSISTOR, FET,. N-CHANNEL	393314	89536	393314	REF		
Q18	TRANSISTOR, NPN, SI	585109	89536	585109	1	1	
Q19	TRANSISTOR, NPN, SI	295717	24355	AD811-00/17	1	1	
Q22	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q23	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q31	TRANSISTOR, PNP, SI	195974	04713	2N3906	REF		
Q32	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q33	TRANSISTOR, PNP, SI	195974	04713	2N3906	REF		
Q34	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q35	TRANSISTOR, PNP, SI	195974	04713	2N3906	REF		
Q36	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
Q37	TRANSISTOR, PNP, SI	218388	07263	PN3645	1	1	
Q38	TRANSISTOR, NPN, SI	218396	04713	2N3904	REF		
R1	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	1		
R2	RES, MTL. FILM, 28.0K +/-1%, 1/8W	291385	91637	CMF552802F	2		
R3	RES, MTL. FILM, 28.0K +/-1%, 1/8W	291385	91637	CMF552802F	REF		
R4	RES, MTL. FILM, 21K +/-1%, 1/8W	441212	91637	CMF552102F	2		
R5	RES, MTL. FILM, 17.8K +/-1%, 1/8W	349183	91637	CMF551782F	2		
R6	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	1		
R7	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	5		
R8	RES, COMP, 150K +/-5%, 2W	110122	01121	HB1545	1		
R9	RES, COMP, 150K +/-10%, 1/2W	108167	01121	EB15415	1		
R10	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R11	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R12	RES, DEP. CAR, 15 +/-5%, 1/4W	348755	80031	CR251-4-5P15E	2		
R13	RES, DEP. CAR, 15 +/-5%, 1/4W	348755	80031	CR251-4-5P15E	REF		
R15	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	4		
R16	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	8		
R17	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R18	RES, MTL. FILM, 21K +/-1%, 1/8W	441212	91637	CMF552102F	REF		
R19	RES, MTL. FILM, 17.8K +/-1%, 1/8W	349183	91637	CMF551782F	REF		
R21	RES, DIVIDER SET	434605	89536	434605	1	1	
R22	(PART OF R21 SET)				REF		
R23	(PART OF R21 SET)				REF		
R24	RES, DC RANGE SET	409938	89536	409938	1	1	
R25	(PART OF R24 SET)				REF		
R26	(PART OF R24 SET)				REF		
R30	RES, DEP. CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	1		
R31	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R32	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R33	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R34	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R35	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	CMF551004F	2		
R36	RES, CERMET, 100M +/-10%, 1W	441758	89536	441758	1		
R47	RES, VAR, CERMET, 200 +/-20%, 1/2W	284711	71450	190PC201B	1		
R48	RES, VAR, CERMET, 50 +/-20%. 1/2W	267815	71450	190PC500B	2		
R49	RES, VAR, CERMET, 50 +/-20%. 1/2W	267815	71450	190PC500B	REF		

Table 5-12. A8 DC Signal Conditioner PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R50	RES, DEP. CAR, 2.2 +/-5%, 1/4W	354944	80031	CR251-4-5P2E2	1		
R51	RES, DEP. CAR, 20 +/-5%, 1/4W	442202	80031	CR251-4-5P20E	1		
R52	RES, VAR, CERMET, 100K +/-20%. 1/2W	268581	71450	190PC104B	1		
R53	RES, VAR, CERMET, 10K +/-20%, 1/2W	267880	71450	190PC103B	1		
R54	RES, SELECTED, DURING TEST				4		
R55	RES, SELECTED, DURING TEST				REF		
R56	RES, SELECTED, DURING TEST				REF		
R57	RES, SELECTED, DURING TEST				REF		
R58	RES, SET, MATCHED	290320	89536	290320	1	1	
R59	(PART OF R58 SET)				REF		
R61	RES, MTL. FILM, 86.6K +/-1%, 1/8W	291468	91637	CMF558662F	1		
R62	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	CMF551004F	REF		
R63	RES, MTL. FILM, 1.87K +/-1%, 1/8W	267229	91637	CMF551871F	1		
R64	RES, MTL. FILM, 1K +/-1%, 1/8W	168229	91637	CMF551001F	1		
R70	RES, MTL. FILM, 52.3K +/-1%, 1/8W	237248	91637	CMF555232	1		
R71	RES, MTL. FILM, 3.01K +/-1%, 1/8W	312645	91637	CMF553011F	1		
R72	RES, MTL. FILM, 3.65K +/-1%, 1/8W	293779	91637	CMF553651F	2		
R73	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	CMF551003F	2		
R74	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	CMF551003F	REF		
R75	RES, MTL. FILM, 80.6K +/-1%, 1/8W	281121	91637	CMF558062F	2		
R76	RES, MTL. FILM, 4.02 +/-1%, 1/8W	235325	91637	CMF554021F	1		
R77	RES, MTL. FILM, 200K +/-1%, 1/8W	261701	91637	CMF552003F	1		
R87	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R88	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R89	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R90	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R91	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R92	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R93	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R94	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R95	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R97	RES, MTL. FILM, 3.65K +/-1%, 1/8W	293779	91637	CMF553651F	REF		
R98	RES, MTL. FILM, 2.15K +/-1%, 1/8W	293712	91637	CMF552151F	1		
R99	RES, MTL. FILM, 80.6K +/-1%, 1/8W	281121	91637	CMF558062F	REF		
U1	⊗IC, COS/MOS, QUAD CLOCKED D LATCH	355149	02735	CD4042BE	1	1	
U2	⊗IC, C-MOS, TRIPLE 3 INPUT NAND GATES	375147	02735	CD4023UBE	1	1	
U3	IC, OP AMP, J-FET	357830	12040	LH0042C	2	1	
U4	IC, OP AMP, J-FET	357830	12040	LH0042C	REF		
U5	IC, OP AMP	271502	12040	LM301A	2	1	
U6	IC, OP AMP	271502	12040	LM301A	REF		

1 SEE TABLE 5-17 AT THE END OF SECTION 5.

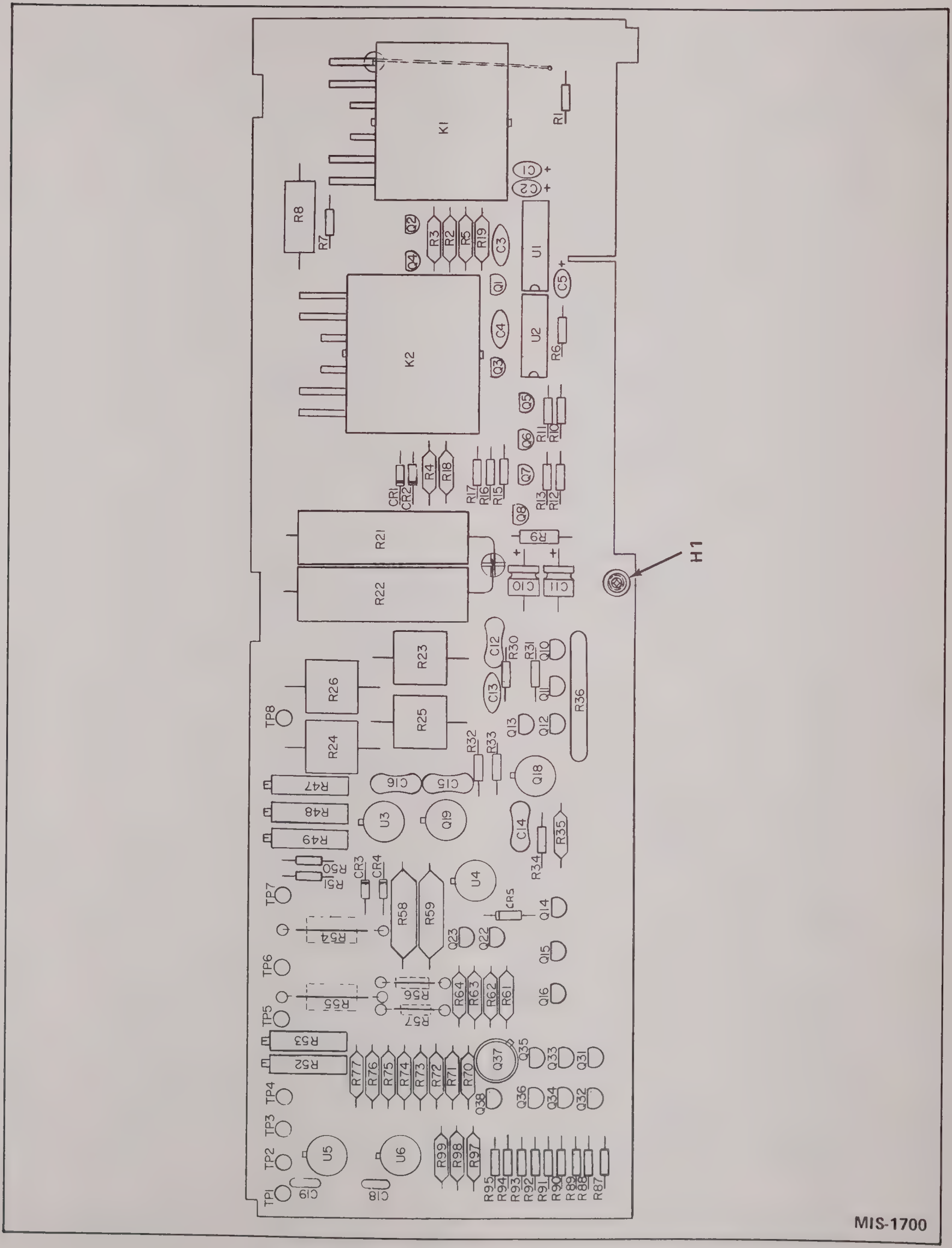

K1
R1
C1
C2
R8
R7
Q2
Q4
R3
R2
R5
R19
C3
U1
C5
Q1
K2
C4
U2
R6
Q3
Q5
R11
R10
Q6
Q7
R13
R12
CR1
CR2
R4
R18
R17
R16
R15
Q8
R9
R21
R22
C10
C11
H1
C12
R30
R31
Q10
C13
Q11
R36
R23
R26
R25
TP8
R24
Q13
Q12
R32
R33
Q18
R47
C16
C15
R48
U3
Q19
R49
C14
R35
R34
CR3
CR4
R50
R51
U4
TP7
R58
R59
CR5
Q14
R54
Q23
Q22
Q15
TP6
R56
R64
R63
R62
R61
Q16
R55
R57
TP5
R53
Q35
Q33
Q31
R52
R77
R76
R75
R74
R73
R72
R71
R70
Q37
TP4
Q38
Q36
Q34
Q32
TP3
TP2
U5
U6
R99
R98
R97
TP1
C19
C18
R95
R94
R93
R92
R91
R90
R89
R88
R87
MIS-1700

Figure 5-12. A8 DC Signal Conditioner PCB Assembly

Table 5-13. A9 Active Filter PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A9	⊗ACTIVE FILTER PCB ASSEMBLY FIGURE 5-13 (MIS-4130T)	383976	89536	383976	REF		
C1	CAP, POLYPROP, 0.047 UF +/-10%, 50V	413328	89536	413328	3		
C2	CAP, POLYPROP, 0.047 UF +/-10%, 50V	413328	89536	413328	REF		
C3	CAP, POLYPROP, 0.047 UF +/-10%, 50V	413328	89536	413328	REF		
C4	CAP, MICA, 33 PF +/-5%, 500V	160317	02799	DM15E330J	4		
C5	CAP, POLYPROP, 0.47 UF +/-10%, 50V	363085	89536	363085	3		
C6	CAP, POLYPROP, 0.47 UF +/-10%, 50V	363085	89536	363085	REF		
C7	CAP, POLYPROP, 0.47 UF +/-10%, 50V	363085	89536	363085	REF		
C8	CAP, MICA, 33 PF +/-5%, 500V	160317	02799	DM15E330J	REF		
C9	CAP, MICA, 33 PF +/-5%, 500V	160317	02799	DM15E330J	REF		
C10	CAP, MICA, 33 PF +/-5%, 500V	160317	02799	DM15E330J	REF		
C11	CAP, ELECT, 6.8 UF -10/+50%, 63V	218966	73445	ET6P8X063A3	2		
C12	CAP, ELECT, 10 UF -10/+50%, 25V	170266	73445	ET100X025A2	2		
C13	CAP, ELECT, 10 UF -10/+50%, 25V	170266	73445	ET100X025A2	REF		
C14	CAP, ELECT, 6.8 UF -10/+50%, 63V	218966	73445	ET6P8X063A3	REF		
C15	CAP, POLYPROP, 0.0022 UF +/-10%, 200V	442632	89536	442632	1		
CR1	DIODE, ZENER	260695	07910	1N754A	1	1	
CR2	DIODE, ZENER	386557	07910	1N960A	1	1	
CR3	DIODE, SI, HI SPEED SWITCHING	203323	07910	1N4448	1	1	
H1	SCREW, PHP, 4-40 X 3/8 (NOT SHOWN)	256164	89536	256164	1		
MP1	CASE, ASSY (INCLUDES MP2-MP9)	458976	89536	458976	1		1
MP2	CASE HALF	402990	89536	402990	REF		
MP3	CASE HALF	402990	89536	402990	REF		
MP4	COVER, CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411959	89536	411959	REF		
MP6	DECAL, ACTIVE FILTER ASSY	413443	89536	413443	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP10	SPACER (USE W/Q26) (NOT SHOWN)	152207	07047	10123DAP	1		
MP11	SOCKET (USE W/R15, R16) (NOT SHOWN)	343285	00779	2-331272-6	4		
MP12	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380M	1		
Q1	TRANSISTOR, SI, PNP	195974	04713	2N3906	6	2	
Q2	TRANSISTOR, SI, NPN	218396	04713	2N3904	9	2	
Q3	TRANSISTOR, SI, PNP	195974	04713	2N3906	REF		
Q4	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q5	TRANSISTOR, SI, PNP	195974	04713	2N3906	REF		
Q6	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q7	TRANSISTOR, SI, PNP	195974	04713	2N3906	REF		
Q8	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q9	TRANSISTOR, SI, PNP	195974	04713	2N3906	REF		
Q10	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q11	TRANSISTOR, SI, PNP	195974	04713	2N3906	REF		
Q12	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q13	TRANSISTOR, SI, PNP	226290	04713	MPS3640	1	1	
Q14	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	15	3	
Q15	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q16	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q17	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q18	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q19	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		

Table 5-13. A9 Active Filter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q20	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q21	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q22	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q23	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q24	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q25	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q26	TRANSISTOR, SI, PNP	218388	07263	PN3645	1	1	
Q27	TRANSISTOR, SI, NPN	284075	32293	ITS1099	1	1	
Q28	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q29	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q30	TRANSISTOR, SI, NPN	218396	04713	2N3904	REF		
Q31	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q32	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
Q33	TRANSISTOR, FET, N-CHANNEL	393314	17856	J086	REF		
R1	RES, DEP. CAR, 6.2K +/-5%, 1/4W	442368	80031	CR251-4-5P6K2	1		
R2	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R3	RES, MTL. FILM, 51.1K +/-5%, 1/8W	289553	91637	CMF555112F	1		
R4	RES, DEP. CAR, 8.2K +/-5%, 1/4W	441675	80031	CR251-4-5P8K2	2		
R5	RES, DEP. CAR, 8.2K +/-5%, 1/4W	441675	80031	CR251-4-5P8K2	REF		
R8	RES, MTL. FILM, 45.3K +/-1%, 1/8W	234971	91637	CMF554532F	4		
R9	RES, MTL. FILM, 45.3K +/-1%, 1/8W	234971	91637	CMF554532F	REF		
R10	RES, MTL. FILM, 45.3K +/-1%, 1/8W	234971	91637	CMF554532F	REF		
R11	RES, MTL. FILM, 45.3K +/-1%, 1/8W	234971	91637	CMF554532F	REF		
R12	RES, MTL. FILM, 12.1K +/-1%, 1/8W	234997	91637	CMF551212F	3		
R13	RES, MTL. FILM, 4.87K +/-1%, 1/8W	294850	91637	CMF554871F	1		
R14	RES, VAR, CERMET, 20K +/-10%, 1/2W	291609	89536	291609	1		
R15	RES, SELECTED, DURING TEST						
R16	RES, SELECTED, DURING TEST						
R17	RES, MTL. FILM, 1M +/-1%, 1/2W	327510	91637	CMF651004F	2		
R18	RES, MTL. FILM, 1M +/-1%, 1/2W	327510	91637	CMF651004F	REF		
R19	RES, MTL. FILM, 12.1K +/-1%, 1/8W	234997	91637	CMF551212F	REF		
R20	RES, MTL. FILM 249K +/-1%, 1/8W	268805	91637	CMF552493F	2		
R21	RES, MTL. FILM, 57.6K +/-1%, 1/8W	289116	91637	CMF555762F	1		
R22	RES, MTL. FILM, 12.1K +/-1%, 1/8W	234997	91637	CMF551212F	REF		
R23	RES, MTL. FILM, 249K +/-1%, 1/8W	268805	91637	CMF552493F	REF		
R24	RES, DEP. CAR, 15 +/-5%, 1/4W	348755	80031	CR251-4-5P15E	2		
R25	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	2		
R26	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	REF		
R27	RES, DEP. CAR, 15 +/-5%, 1/4W	348755	80031	CR251-4-5P15E	REF		
R28	RES, MTL. FILM, 26.7K +/-1%, 1/8W	245779	91637	CMF552672F	2		
R29	RES, MTL. FILM, 26.7K +/-1%, 1/8W	245779	91637	CMF552672F	REF		
U1	⊗IC, C-MOS, HEX "D" FLIP FLOP	404509	12040	MM74C174N	1	1	
U2	⊗IC, C-MOS, TRIPLE 3-INPUT NAND GATES	375147	02735	CD4023UBE	1	1	
U3	IC, LINEAR, OP AMP	363515	12040	LM301AN	2	1	
U4	IC, LINEAR, OP AMP	363515	12040	LM301AN	REF		
U5	IC, LINEAR, OP AMP	392902	12040	LM1436H	1	1	
U6	RESISTOR NETWORK, 100K +/-5%, 1/4W	404749	89536	404749	1	1	
U7	RESISTOR NETWORK, 100K +/-5%, 1/4W	380618	89536	380618	1	1	

1 SEE TABLE 5-17 AT THE END OF SECTION 5.

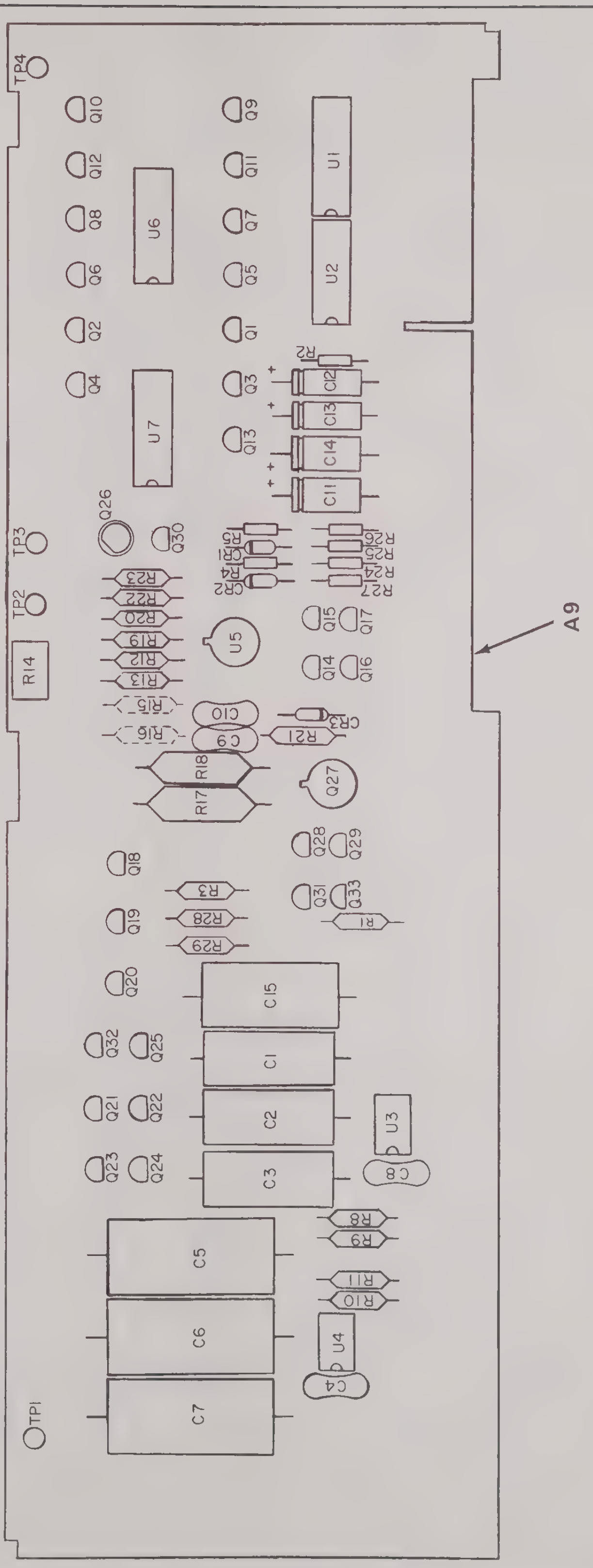

TP4
Q10
Q9
Q12
Q11
U1
Q8
U6
Q7
Q6
Q5
U2
Q2
Q1
R2
Q4
Q3
C12
C13
U7
Q13
C14
C11
Q26
TP3
Q30
R5
CR1
R4
CR2
R26
R25
R24
R27
R23
R22
TP2
R20
Q15
Q17
R19
U5
R12
R14
Q14
Q16
R13
R15
C10
CR3
R16
C9
R21
R18
Q27
R17
Q28
Q29
Q18
R3
Q31
Q33
Q19
R28
R1
R29
Q20
C15
Q32
Q25
C1
Q21
Q22
C2
U3
Q23
Q24
C3
C8
R8
R9
C5
R11
R10
C6
U4
C4
TP1
C7
A9
MIS-1730

Figure 5-13. A9 Active Filter PCB Assembly

Table 5-14. A10 Fast R^2 A/D Converter Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A10	FAST R^2 A/D CONVERTER ASSEMBLY FIGURE 5-14 (MIS-4140T)	383984	89536	383984	REF		
A10A1	A/D ANANLOG PCB ASSEMBLY	ORDER	NEXT	HIGHER ASSEMBLY			
A10A2	A/D DIGITAL PCB ASSEMBLY	ORDER	NEXT	HIGHER ASSEMBLY			
MP1	CASE ASSY (INCLUDES MP2-MP9)	458968	89536	458968	1		1
MP2	CASE HALF	402990	89536	402990	REF		
MP3	CASE HALF, MODIFIED	402982	89536	402982	REF		
MP4	COVER, CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411967	89536	411967	REF		
MP6	DECAL, FAST RR CONVERTER ASSY	413450	89536	413450	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383315	89536	383315	REF		
MP10	SPACER	152207	07047	10123DAP	3		

1 SEE TABLE 5-17 AT THE END OF SECTION 5.

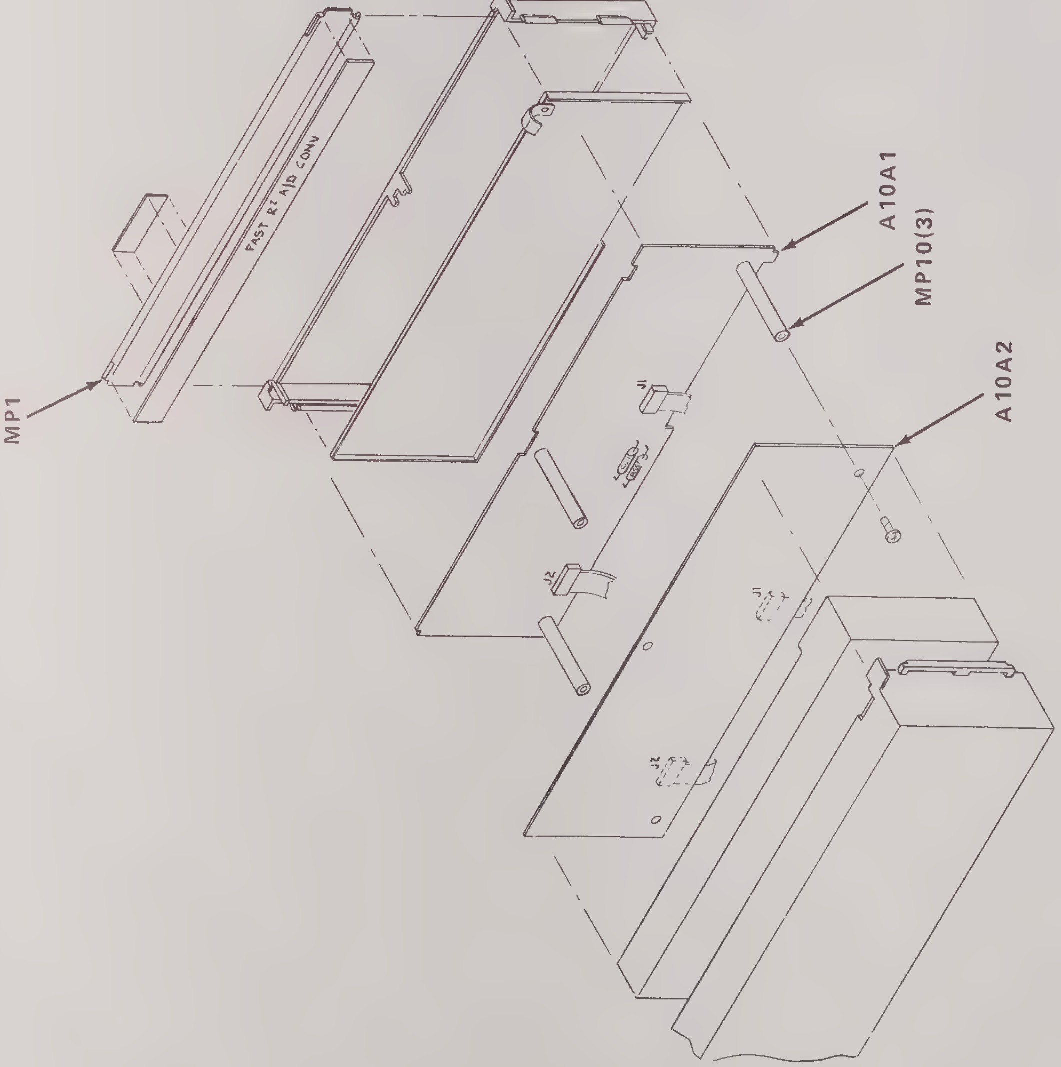

MP1
FAST R² A/D CONV
A10A1
MP10(3)
J1
J2
A10A2
MIS-4140

Figure 5-14. A10 Fast R^2 A/D Converter Assembly

Table 5-15. A10A1 A/D Analog PCB Assembly

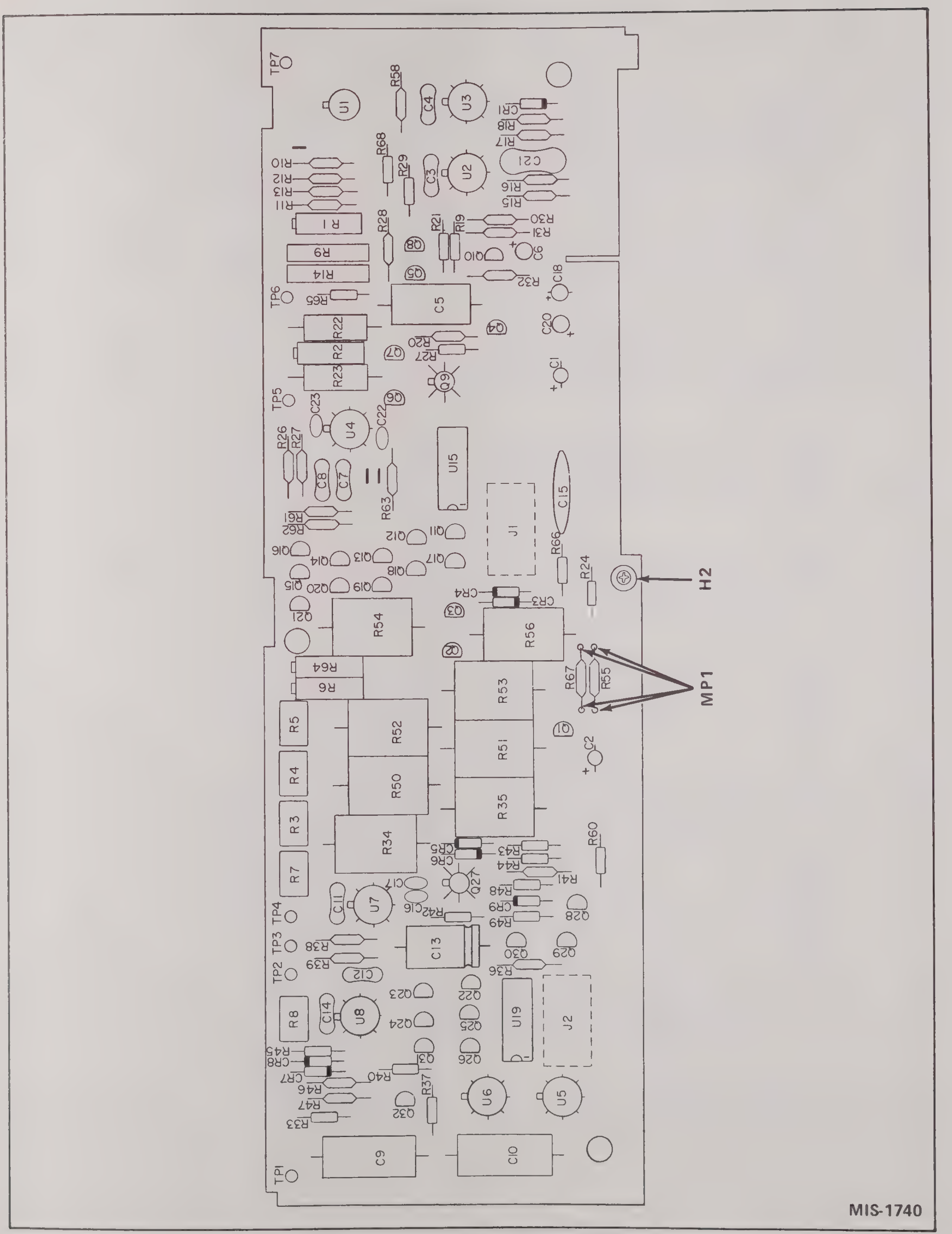
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A10A1	A/D ANALOG PCB ASSEMBLY FIGURE 5-15 (MIS-4140)	383752	89536	383752	REF		
C1	CAP, TA, 10 UF +/-20%, 35V	417683	56289	196D106X0035KA1	2		
C2	CAP, TA, 10 UF +/-20%, 35V	417683	56289	196D106X0035KA1	REF		
C3	CAP, MICA, 33 PF +/-5%, 500V	160317	72136	DM15E330J	1		
C4	CAP, MICA, 30 PF +/-5%, 500V	340570	72136	DM15E300J	1		
C5	CAP, FILM, 0.22 UF +/-10%, 80V	159392	56289	192P2249R8	1		
C6	CAP, TA, 4.7 UF +/-20%, 25V	161943	56289	196D475X0025KA1	1		
C7	CAP, MICA, 150 PF +/-5%, 500V	148478	72136	DM15F151J	2		
C8	CAP, MICA, 150 PF +/-5%, 500V	148478	72136	DM15F151J	REF		
C9	CAP, POLYST, 0.047 UF +/-10%, 100V	260562	84411	863UW47391	2		
C10	CAP, POLYST, 0.047 UF +/-10%, 100V	260562	84411	863UW47391	REF		
C11	CAP, MICA, 47 PF +/-5%, 500V	148536	72136	DM15E470J	3		
C12	CAP, MICA, 47 PF +/-5%, 500V	148536	72136	DM15E470J	REF		
C13	CAP, ELECT, 470 UF -10/+50%, 6.3V	187773	80031	ET471X6P3A6	1		
C14	CAP, MICA, 47 PF +/-5%, 500V	148536	72136	DM15E470J	REF		
C15	CAP, CER, 0.0047 UF +/-10%, 500V	106724	71590	CF-472	1		
C16	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	4		
C17	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C18	CAP, TA, 68 UF +/-20%, 25V	446450	56289	196D686X0025TE4	1		
C20	CAP, TA, 0.22 UF +/-20%, 35V	161331	56289	196D224X0035HA1	1		
C21	CAP, MICA, 1800 PF +/-5%, 500V	148353	72136	DM19F182J	1		
C22	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C23	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
CR1	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	2	1	
CR3	DIODE, SI LO-CAP, LO-LEAK	348177	07263	FD7223	4	1	
CR4	DIODE, SI LO-CAP, LO-LEAK	348177	07263	FD7223	REF		
CR5	DIODE, SI, CONTROLLER FWD VOL	234468	07910	TD9039	2	1	
CR6	DIODE, SI, CONTROLLER FWD VOL	234468	07910	TD9039	REF		
CR7	DIODE, SI LO-CAP, LO-LEAK	348177	07263	FD7223	REF		
CR8	DIODE, SI LO-CAP, LO-LEAK	348177	07263	FD7223	REF		
CR9	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
H1	SCREW, PHP, 4-40 X 1/4 (NOT SHOWN)	256156	89536	256156	3		
H2	SCREW, RHP, 4-40 X 3/8	256164	89536	256164	1		
J1	SOCKET	276535	91506	316-AG39D	2		
J2	SOCKET	276535	91506	316-AG39D	REF		
MP1	SOCKET, COMP. LEAD (TO R55, R67)	343285	00779	2-331272-6	4		
MP2	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	1		
MP3	SPACER, XSTR, (NOT SHOWN)	152207	07047	10123-DAP	1		
Q1	TRANSISTOR, FET (SELECTED)	256487	89536	256487	1	1	
Q2	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q3	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q4	TRANSISTOR, FET, N-CHANNEL	343830	89536	343830	5	1	
Q5	TRANSISTOR, FET, N-CHANNEL	343830	89536	343830	REF		
Q6	TRANSISTOR, FET, N-CHANNEL	343830	89536	343830	REF		
Q7	TRANSISTOR, FET, N-CHANNEL	343830	89536	343830	REF		
Q8	TRANSISTOR, FET, N-CHANNEL	343830	89536	343830	REF		
Q9	TRANSISTOR, FET, DUAL, N-CHANNEL	376087	89536	376087	2	1	
Q10	TRANSISTOR, SI, NPN	218396	04713	2N3904	1	1	

Table 5-15. A10A1 A/D Analog PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q11	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q12	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q13	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q14	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q15	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q16	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q17	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	12	3	
Q18	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q19	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q20	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q21	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q22	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q23	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q24	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q25	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q26	TRANSISTOR, FET (SELECTED)	256487	89536	256487	REF		
Q27	TRANSISTOR, FET, DUAL, N-CHANNEL	376087	89536	376087	REF		
Q28	TRANSISTOR, SI, PNP	195974	04713	2N3906	1	1	
Q29	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q30	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q31	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
Q32	TRANSISTOR, FET, N-CHANNEL	261578	89536	261578	REF		
R1	RES, VAR, CERMET, 500 +/-20%, 1/2W	267849	75378	190PC501B	1		
R2	RES, VAR, CERMET, 10 +/-20%, 1/2W	344135	75378	190PC100B	2		
R3	RES, VAR, CERMET, 500 +/-10%, 1/2W	291120	89536	291120	1		
R4	RES, VAR, CERMET, 200+/-10%, 1/2W	285148	89536	285148	1		
R5	RES, VAR, CERMET, 50 +/-10%, 1/2W	285122	89536	285122	2		
R6	RES, VAR, CERMET, 20 +/-20%, 1/2W	261180	75378	190PC200B	1	1	
R7	RES, VAR, CERMET, 50 +/-10%, 1/2W	285122	89536	285122	REF		
R8	RES, VAR, CERMET, 50K +/-10%, 1/2W	288290	89536	288290	1		
R9	REF. AMP SET (U1,R9,R14,R15,R16)	415034	89536	415034	REF		
R10	RES, MTL. FILM, 3.4K +/-1%, 1/8W	260323	91637	MFF1-83401F	1		
R11	RES, MTL. FILM, 12.1 +/-1%, 1/8W	296608	91637	MFF1-812R1F	2		
R12	RES, MTL. FILM, 24.3 +/-1%, 1/8W	281816	91637	MFF1-824R3F	1		
R13	RES, MTL. FILM, 12.1 +/-1%, 1/8W	296608	91637	MFF1-812R1F	REF		
R14	REF. AMP SET (U1,R9,R14,R15,R16)	415034	89536	415034	REF		
R15	REF. AMP SET (U1,R9,R14,R15,R16)	415034	89536	415034	REF		
R16	REF. AMP SET (U1,R9,R14,R15,R16)	415034	89536	415034	REF		
R17	RES, MTL. FILM, 10K +/-1%, 1/8W	328120	91637	MFF1-81002F	2		
R18	RES, MTL. FILM, 10K +/-1%, 1/8W	328120	91637	MFF1-81002F	REF		
R19	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	3		
R20	RES, MTL. FILM, 10K +/-1%, 1/8W	168260	91637	MFF1-81002F	3		
R21	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R22	RES SET (R22, R23)	409896	89536	409896	1		
R23	RES SET (R22, R23)	409896	89536	409896	REF		
R24	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	1		
R25	RES, MTL. FILM, 42.2K +/-1%, 1/8W	221655	91637	MFF1-84222F	2		
R26	RES, MTL. FILM, 42.2K +/-1%, 1/8W	221655	91637	MFF1-84222F	REF		
R27	RES, DEP. CAR, 62 +/-5%, 1/4W	441634	80031	CR251-4-5P62E	1		
R28	RES, MTL. FILM, 10K +/-1%, 1/8W	168260	91637	MFF1-81002F	3		

Table 5-15. A10A1 A/D Analog PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R29	RES, DEP. CAR, 33K +/-5%, 1/4W	348888	80031	CR251-4-5P33K	2		
R30	RES, MTL. FILM, 10K +/-1%, 1/8W	168260	91637	MFF1-81002F	REF		
R31	RES, MTL. FILM, 11.3K +/-1%, 1/8W	293639	91637	MFF1-81132F	1		
R32	RES, MTL. FILM, 24.9K +/-1%, 1/8W	291369	91637	MFF1-82492F	1		
R33	RES, DEP. CAR, 47 +/-5%, 1/4W	441592	80031	CR251-4-5P47E	2		
R34	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	1	1	
R35	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	REF		
R36	RES, MTL. FILM, 26.7K +/-1%, 1/8W	245779	91637	MFF1-82672F	1		
R37	RES, DEP. CAR, 47 +/-5%, 1/4W	441592	80031	CR251-4-5P47E	REF		
R38	RES, MTL. FILM, 75K +/-1%, 1/8W	291443	91637	MFF1-87502F	3		
R39	RES, MTL. FILM, 75K +/-1%, 1/8W	291443	91637	MFF1-87502F	REF		
R40	RES, DEP. CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	2		
R41	RES, MTL. FILM, 75K +/-1%, 1/8W	291443	91637	MFF1-87502F	REF		
R42	RES, DEP. CAR, 3K +/-5%, 1/4W	441527	80031	CR251-4-5P3K	1		
R43	RES, DEP. CAR, 510 +/-5%, 1/4W	441600	80031	CR251-4-5P510E	1		
R44	RES, DEP. CAR, 1.5K +/-5%, 1/4W	343418	80031	CR251-4-5P1K5	1		
R45	RES, DEP. CAR, 470K +/-5%, 1/4W	342634	80031	CR251-4-5P470K	1		
R46	RES, MTL. FILM, 665 +/-1%, 1/8W	320028	91637	MFF1-86650F	1		
R47	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	MFF1-81004F	1		
R48	RES, DEP. CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	REF		
R49	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R50	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	REF		
R51	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	REF		
R52	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	REF		
R53	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	REF		
R54	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	REF		
R55	RES, MTL. FILM, 56.2 +/-1%, 1/8W	305938	91637	MFF1-856R2F	1		
R56	RES SET (R34,R35,R50-54,R56)	409946	89536	409946	REF		
R58	RES, MTL. FILM, 2573 +/-0.1%, 1/8W	321463	91637	MFF1-82573F	1		
R60	RES, DEP. CAR, 33K +/-5%, 1/4W	348888	80031	CR251-4-5P33K	REF		
R61	RES, MTL. FILM, 57.6K +/-1%, 1/8W	289116	91637	MFF1-85762F	1		
R62	RES, MTL. FILM, 66.5K +/-1%, 1/8W	289082	91637	MFF1-86652F	1		
R63	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	MFF1-81003F	1		
R64	RES, VAR, CERMET, 10 +/-20%, 1/2W	344135	75378	190PC100B	REF		
R65	RES, DEP. CAR, 820 +/-5%, 1/4W	442327	80031	CR251-4-5P820E	1		
R66	RES, DEP. CAR, 5.1K +/-5%, 1/4W	368712	80031	CR251-4-5P5K1	1		
R67	RES, MTL. FILM, 18.7 +/-1%, 1/8W	441776	91637	MFF1-812R7F	1		
R68	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	1		
U1	REF. AMP SET (U1,R9,R14,R15,R16)	415034	89536	415034	1	1	
U2	IC, OP AMP	271502	12040	LM301A	2	1	
U3	IC, OP AMP	271502	12040	LM301A	REF		
U4	IC, OP AMP, J-FET, INPUT	310037	12040	LH0042CH	2	1	
U5	IC, LIN, VOL, FOLLOWER	288365	12040	LM310H	2	1	
U6	IC, LIN, VOL, FOLLOWER	288365	12040	LM310H	REF		
U7	IC, OP AMP, J-FET, INPUT	310037	12040	LH0042CH	REF		
U8	IC, OP AMP	225961	24355	AD3092	1	1	
U15	RES NETWORK, 33K	413146	89536	413146	1	1	
U19	RES NETWORK, 100K	380618	89536	380618	1	1	


TP7
TP6
TP5
TP4
TP3
TP2
TP1
U1
U2
U3
U4
U5
U6
U7
U8
U15
U19
J1
J2
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
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R68
C1
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C13
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C20
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C22
C23
CR1
CR3
CR4
CR5
CR6
CR7
CR8
CR9
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q16
Q17
Q18
Q19
Q20
Q21
Q22
Q23
Q24
Q25
Q26
Q27
Q28
Q29
Q30
Q31
Q32
H2
MP1
MIS-1740

Figure 5-15. A10A1 A/D Analog PCB Assembly

Table 5-16. A10A2 Fast R^2 A/D Converter Digital PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A10A2	⊗FAST R^2 A/D CONV DGTL PCB ASSEMBLY FIGURE 5-16 (MIS-4141)	383760	89536	383760	REF		
C1	CAP, TA, 220 UF +/-20%, 6V	408682	56289	196D227X0006TE4	2		
C2	CAP, MICA, 82 PF +/-5%, 500V	148502	72136	DM15F820J	2		
C3	CAP, MICA, 82 PF +/-5%, 500V	148502	72136	DM15F820J	REF		
C4	CAP, TA, 220 UF +/-20%, 6V	408682	56289	196D227X0006TE4	REF		
J1	CABLE ASSY, 16 PIN CONN	380576	08261	5122-003.5	2		
J2	CABLE ASSY, 16 PIN CONN	380576	08261	5122-003.5	REF		
Q1	TRANSISTOR, SI, PNP	226290	04713	MPS3640	1		
R1	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R2	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	2		
R3	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R4	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R5	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	MFF1-81003F	2		
R6	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	MFF1-81003F	REF		
R7	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	1		
U1	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	9	2	
U2	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U3	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	3	1	
U4	RES NETWORK	380618	89536	380618	3	1	
U5	⊗IC, C-MOS, DUAL, COMPLEMENTARY	408013	02735	CD4007AE	1	1	
U6	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U7	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	REF		
U8	⊗IC, C-MOS, QUAD, 2-INPUT NAND GATES	355198	02735	CD4011AE	2	1	
U11	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U12	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U13	RES NETWORK	380618	89536	380618	REF		
U14	IC, LINEAR, 5 XSTR ARRAY	380188	02735	CA3183E	3	1	
U15	IC, LINEAR, 5 XSTR ARRAY	380188	02735	CA3183E	REF		
U16	⊗IC, C-MOS, QUAD, 2-INPUT OR GATE	408393	02735	CD4071BE	2	1	
U17	IC, LINEAR, 5 XSTR ARRAY	380188	02735	CA3183E	REF		
U21	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	REF		
U22	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U23	IC, LINEAR, 5 XSTR ARRAY	477778	89536	477778	2	1	
U25	⊗IC, C-MOS, QUAD, 2-INPUT AND GATE	408401	02735	CD4081BE	1	1	
U26	IC, DGTL, C-MOS, QUAD, 2-INPUT OR GATE	408393	02735	CD4071BE	REF		
U31	⊗IC, C-MOS, DIV BY -8, COUNTER/DIV	403360	02735	CD4022AE	1	1	
U32	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U33	⊗IC, C-MOS, QUAD, 2-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U34	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U35	⊗IC, C-MOS, DUAL TYPE D FLIP FLOP	340117	02735	CD4013AE	REF		
U36	⊗IC, C-MOS, QUAD, 2-INPUT NAND GATES	355198	02735	CD4011AE	REF		
U37	RES NETWORK	380618	89536	380618	REF		
U38	IC, LINEAR, 5 XSTR ARRAY	477778	89536	477778	REF		

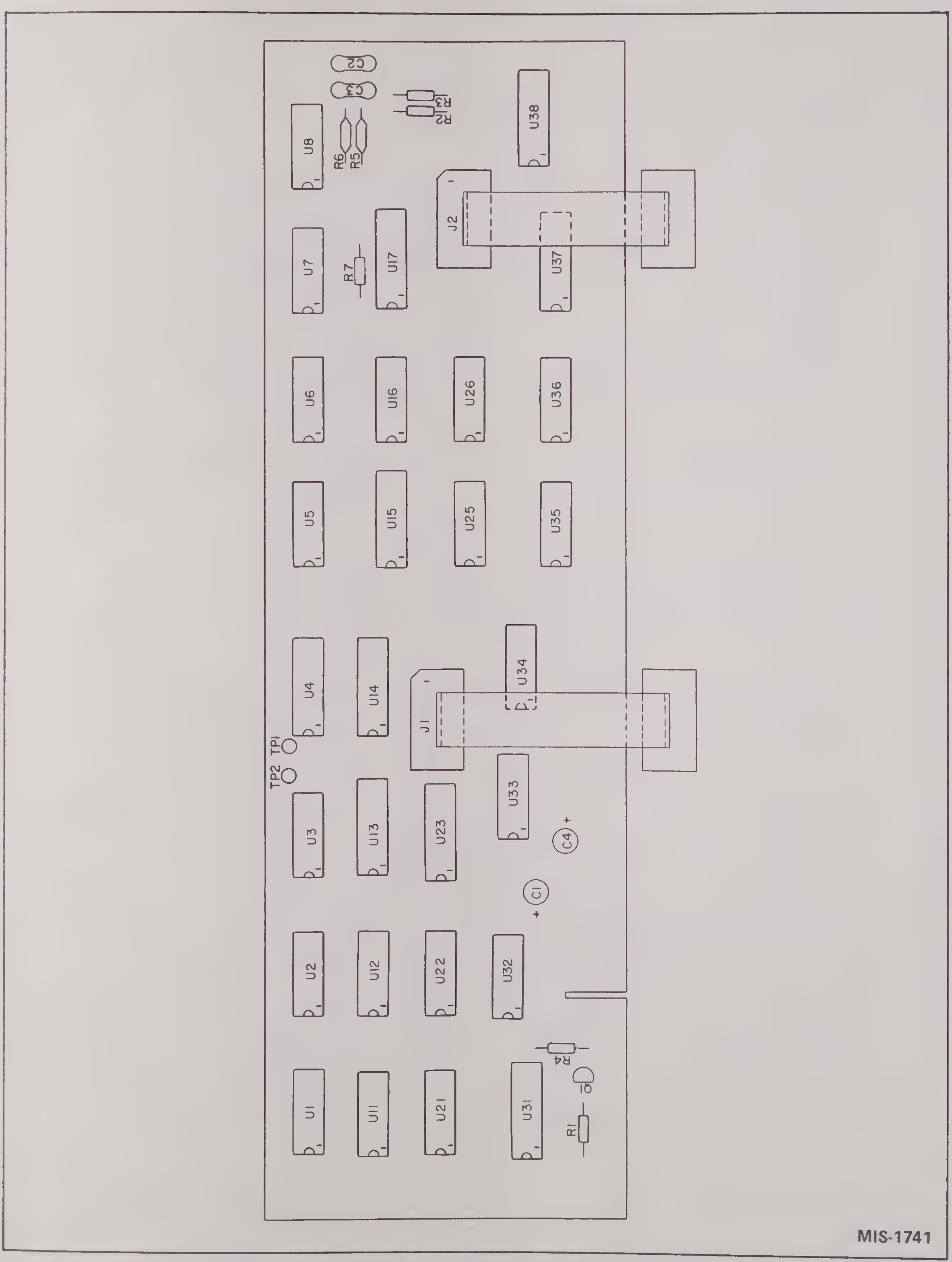

C2
C3
R3
R2
U38
U8
R6
R5
J2
U7
R7
U17
U37
U6
U16
U26
U36
U5
U15
U25
U35
U4
U14
J1
U34
TP1
TP2
U3
U13
U23
U33
C4
C1
U2
U12
U22
U32
R4
U1
U11
U21
U31
R1
MIS-1741

Figure 5-16. A10A2 Fast R^2 A/D Converter Digital PCB Assembly

Table 5-17. Module Case Assembly

PCB ASSY	CASE ASSY	CASE HALF MODULE	CASE HALF MODF'D	COVER MODULE CASE	SHIELD, COVER	DECAL ASSY	DECAL CAUTION	GUARD REAR	GUARD FRONT
A6 OLD	471326	402990	402990	486340	440008	453696	454504	383364	383356
A6 NEW	611665	402990	402990	402974	440008	536029	454504	383364	383356
A8	458992	402990	402990	402974	411918	413377	454504	383364	383356
A9	458976	402990	402990	402974	411959	413443	454504	383364	383356
A10	458968	402990	402982	402974	411967	413450	454504	383364	383315
OPT-01	459016	402990	402990	402974	411926	413385	454504	383364	383356
OPT-02	458927	402990	402990	402974	411942	413435	454504	383364	383356
OPT-03	459008	402990	402990	402974	412015	413419	454504	383364	383356
OPT-04	458919	402990	402990	402974	411975	413484	454504	383364	383356
OPT-05	458935	402990	456079	402974	441022	413518	454504	383364	NONE
OPT-06	458943	402990	412031	402974	411983	413492	454504	383364	NONE
OPT-07	458950	402990	427625	402974	411991	413500	454504	383364	NONE
OPT-08A	459024	402990	402990	402974	437939	413534	454504		
LEFT								437947	487298
RIGHT								383349	487280
OPT-09A	425231	402990	402990	402974	468462	413401	454504	383364	383356

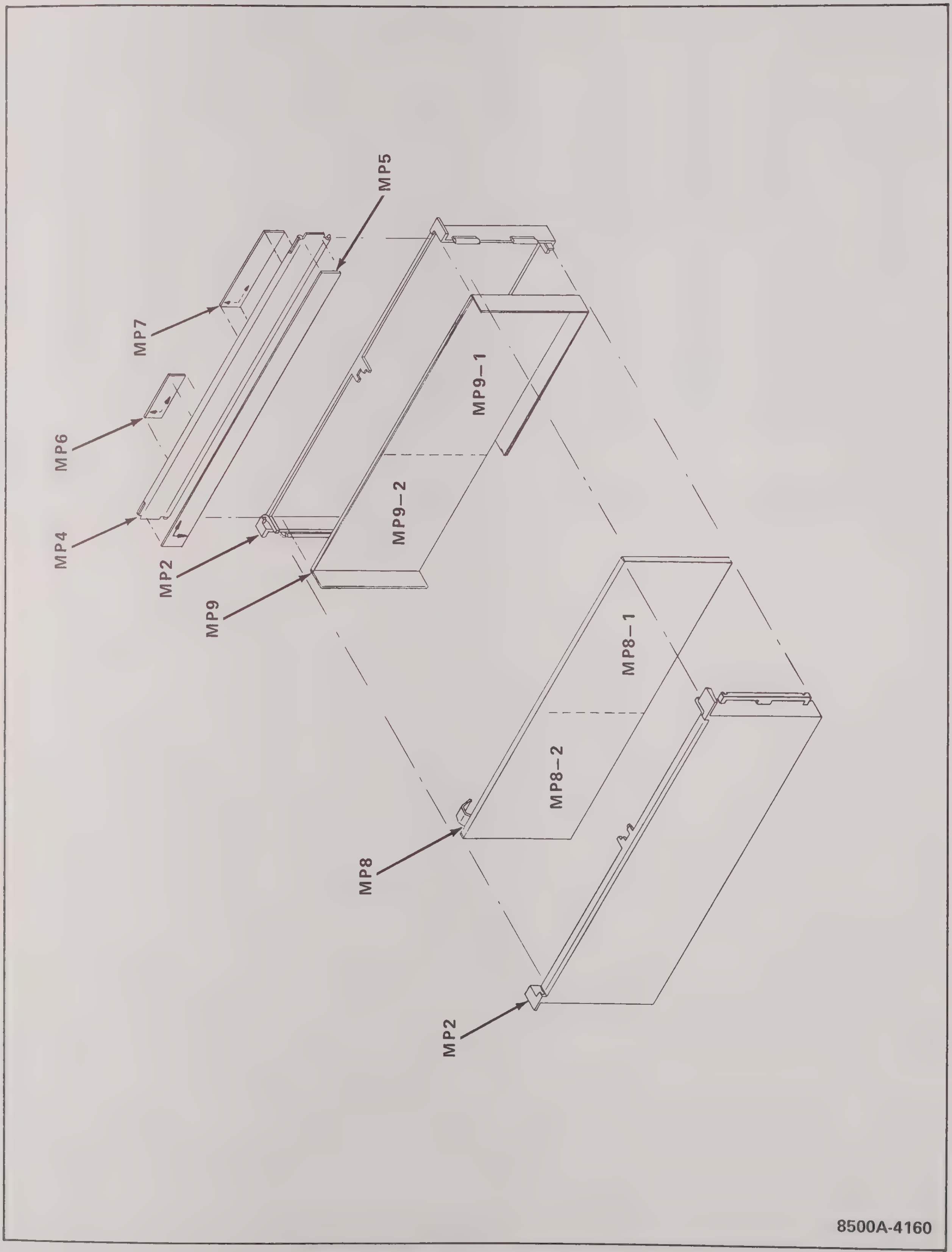

MP5
MP7
MP6
MP4
MP2
MP9
MP9—1
MP9—2
MP8—1
MP8—2
MP8
MP2
8500A-4160

Figure 5-17. MP1 Module Case Assembly

Section 6

Option & Accessory Information

TABLE OF CONTENTS

OPTION/ MODEL NO.	DESCRIPTION	DOCUMENTATION SUPPLIED:	PAGE NO.
	ACCESSORIES		
M04-205-600	Rack Ear Mounting Assembly	Herein	600-1
80F-5	High Voltage Probe	Herein	600-1
80F-15	High Voltage Probe	Herein	600-2
81RF	High Frequency Probe	Herein	600-2
82RF	High Frequency Probe	Herein	600-2
KDM1	Keyboard Display Module	Herein	600-2
	OPTIONS		
–01	AC/DC Converter (Averaging)	With Option	601-1
–02	Ohms Converter	With Option	602-1
–03	Current Shunts	With Option	603-1
–04	Calibration Memory	With Option	604-1
–05	IEEE Standard 488-1975 Interface	With Option	605-1
–06	Bit Serial Asynchronous Interface	With Option	606-1
–07	Parallel Interface	With Option	607-1
–08A	Isolator	With Option	608-1
–09A	AC/DC Converter (RMS)	With Option	609-1
–16	Switchable Front-Rear Inputs	With Option	616-1
–17	Rear Input	With Option	617-1

6-1. INTRODUCTION

6-2. This section of the manual employs modular construction. 8502A accessory information is included first; page and paragraph numbering is described by a 600-X series where X is the page or paragraph number.

6-3. Should you order optional modules with your 8502A, appropriate subsections will be included in this manual. Page and paragraph numbering for any option subsection will be a 6YY-X series where YY is the option number (01, 07, etc.) and X is the page or paragraph number.

6-4. Up-to-date manual subsections will be included with any further options you may order. These subsections can easily be added to this manual.

WARNING

POSSIBILITY OF ELECTRICAL SHOCK EXISTS WHEN OPTION –17 IS INSTALLED. FRONT AND REAR INPUTS ARE PARALLEL CONNECTED; INPUTS APPLIED AT EITHER SET OF TERMINALS WILL BE PRESENT AT THE OTHER. NEVER LEAVE TEST LEADS CONNECTED TO BOTH FRONT AND REAR TERMINALS. ALWAYS REMOVE FRONT PANEL TERMINAL STRAPS WHEN USING THE REAR INPUTS.

Accessories

600-1. RACK EAR MOUNTING ASSEMBLY

600-2. Figure 600-1 illustrates installation of the Rack Ear Mounting Assembly. Use the following procedure.

1. Remove the nameplate decals from handles.
2. Remove the screws from handles.
3. Attach rack ears with # 8 - 32 x 5/8 PHP screws (enclosed in kit).
4. Remove the front screws from top and bottom cover which match the hole pattern in trim items.
5. Attach trim angle on top cover and trim channel on bottom cover with # 6 - 32 x 3/8 PHP screws and lock washer (enclosed in kit).

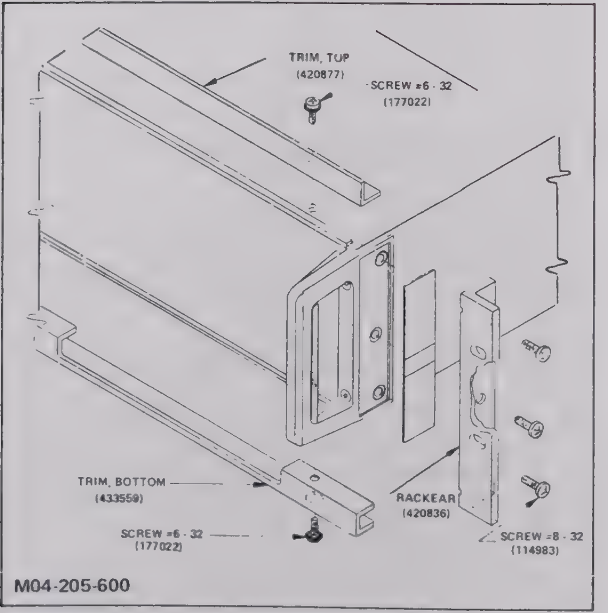


Figure 600-1. Rack Ear Mounting Installation

600-3. HIGH VOLTAGE PROBE (80F-5)

600-4. The Model 80F-5 Voltage Divider shown in Figure 600-2 allows measurement of up to 5k volts dc to be made using FLUKE 800, 900, and 8000 series voltmeters. Division ratio of this accessory is 1000:1. Accuracy and stability of the division ratio is ensured using special metal film resistors having matched temperature coefficients.

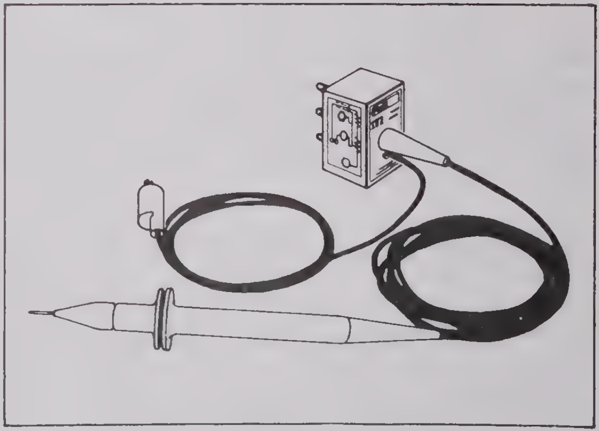


Figure 600-2. 80F5 Voltage Divider

600-5. Physical design of the Model 80F-5 allows direct mating to the input terminals of the FLUKE voltmeters. A high voltage probe facilitates connection to the measurement source. Maintenance is minimized by encapsulation of the divider components.

600-6. Three versions of the Model 80F-5 are available. The basic Model 80F-5 is used with voltmeters having a 10 megohm input resistance. An (01) Option is provided for voltmeters having an 11 megohm input resistance, and an (02) Option is provided for voltmeters having an infinite input resistance (10^3 megohms or greater) at null.

600-7. HIGH VOLTAGE PROBE (80F-15)

600-8. The Accessory Model 80F-15 Voltage Divider, shown in Figure 6-7, allows measurement of up to 15k volts dc to be made using FLUKE 800, 900, and 8000 series voltmeters. Division ratio of this accessory is 1000:1 Accuracy and stability of the division ratio is ensured using special metal film resistors having matched temperature coefficients.

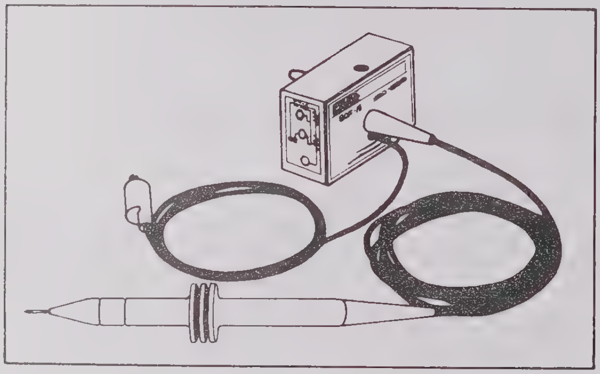


Figure 600-3. 80F15 Voltage Divider

600-9. Physical design of the Model 80F-15 allows direct mating to the input terminals of the FLUKE voltmeters. A high voltage probe facilitates connection to the measurement source. Maintenance is minimized by encapsulation of the divider components.

600-10. Three versions of the Model 80F-15 are available. The basic Model 80F-15 is used with voltmeters having a 10 megohm input resistance. An (01) Option is provided for voltmeters having an 11 megohm input resistance, and an (02) Option is provided for voltmeters having an infinite input resistance (10^3 megohm or greater) at null.

600-11. HIGH FREQUENCY PROBE (81 RF)

600-12. The Model 81RF High Frequency Probe, Figure 600-4, extends the frequency range of the DVM/DMM to include 100 kHz to 100 MHz for ac voltage measurements from 0.25 to 30V rms. The 81RF operates in conjunction with the dc voltage ranges, and is connected to the DVM DMM using a shielded dual-banana plug and, when necessary, a dual banana adaptor.

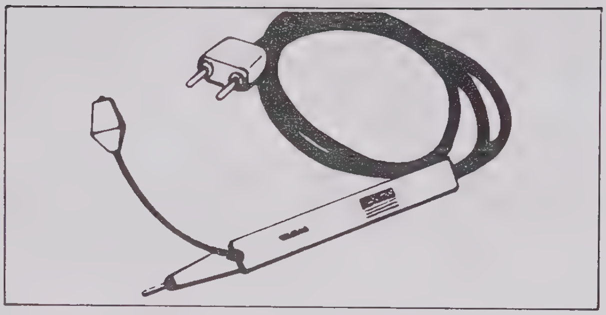


Figure 600-4. 81RF High Frequency Probe

600-13. HIGH FREQUENCY PROBE (82RF)

600-14. The Model 82RF High Frequency Probe, Figure 600-5, allows measurements over a frequency range of 100 kHz to 500 MHz from 0.25 to 30V rms. It is designed to be used with voltmeters having an input impedance of 10 megohms + 10%. It may be used with a voltmeter having an input impedance higher than 10 megohms provided the input is externally shunted to make the equivalent input impedance equal to 10 megohms.

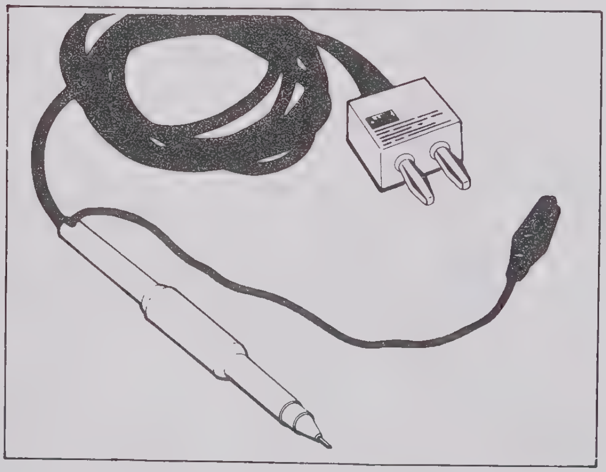


Figure 600-5. 82RF High Frequency Probe

600-15. Circuitry within the 82RF consists of a capacitor-coupled rectifier circuit which responds to the peak value of the input waveform. The output is positive polarity dc which is calibrated to be equivalent to the rms value of a sine wave.

600-16. KEYBOARD DISPLAY MODULE (KDM1)

600-17. The Micon KDM1 Keyboard Display Module is a LED display terminal (with a connecting cable) for use with the Bit Serial Asynchronous Interface (Option –06). Standard ASCII characters are used on the keyboard to facilitate programming the 8500A/AE.

Option —02
Ohms Converter

602-1. INTRODUCTION

602-2. Installation of the Ohms Converter provides precision resistance measurement capability ranging from 100 μΩ to 262 MΩ. Both two-terminal and four-terminal measurements may be made.

602-3. SPECIFICATIONS

602-4. Table 602-1 lists the specifications of the Ohms Converter.

602-5. INSTALLATION

602-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing and removing modules. The interconnect diagram in Section 8 contains a table listing permissible and preferred slots.

602-7. OPERATING NOTES

602-8. Operation of the front panel controls with the Ohms Converter Option installed is the same as described in Section 2 of this manual. Eight ranges are available for resistance measurements: 10, 100, 1K, 10K, 100K, 1M, 10M, and 100M. Ranges may be either manually or automatically selected. Four-wire measurements may be made up through the 100K range. In the 1M, 10M, and 100M ranges only two-wire measurements may be made, as lead resistance will not affect accuracy. However, the four-wire connections may still be used if desired. Sense HI to Source HI and Sense LO to Source LO connections must be made either with the shorting links provided (two-wire mode) or at the resistance to be measured (four-wire mode). Figure 602-1 shows possible connections for both the two-wire and four-wire modes.

Table 602-1. Ohms Converter Specifications

ACCURACY

(Refer to the specifications table in section 1 for required environmental conditions)

Range	NORMAL RESOLUTION Accuracy ± (% of Input + No. of Digits)			HIGH RESOLUTION Accuracy ± (% of Input + No. of Digits		
	24 Hours	90 Days	1 Year	24 Hours	90 Days	1 Year
10Ω	0.003 + 20	0.005 + 20	0.01 + 20	—	—	—
100Ω	0.002 + 2	0.003 + 2	0.006 + 2	0.002 + 14	0.003 + 14	0.006 + 14
1 kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
10kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
100 kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
1 MΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
10 MΩ	0.01 + 1	0.02 + 1	0.04 + 1	0.01 + 8	0. 02 + 8	0.004 + 8
100 MΩ	0.03 + 1	0.05 + 1	0.1 + 1	0.03 + 8	0.05 + 8	0.1 + 8

Table 602-1. Ohms Converter Specifications (Continued)

OPERATING CHARACTERISTICS

Range	Full Scale	Current Through Unknown	Normal Resolution		High Resolution	
			Resolution	Temperature Coefficient* ± (ppm/rdg + No. of Digits)/°C	Resolution	Temperature Coefficient* ± (ppm/rdg + No. of Digits)/°C
10Ω	31.25Ω	10 mA	100 uΩ	8 + 1.5	–	–
100Ω	250Ω	10 mA	1 mΩ	7 + 0.2	100 uΩ	7 + 2
1 kΩ	2 kΩ	1.25 mA	10 mΩ	7 + 0.2	1 mΩ	7 + 2
10 kΩ	32 kΩ	78 uA	100 mΩ	7 + 0.2	10 mΩ	7 + 2
100 kΩ	256 kΩ	9.8 uA	1Ω	7 + 0.2	100 mΩ	7 + 2
1 MΩ	4.096 MΩ	4.9 uA	10Ω	7 + 0.2	1Ω	7 + 2
10 MΩ	32.768 MΩ	0.61 uA	100Ω	30 + 0.2	10Ω	30 + 2
100 MΩ	262.144 MΩ	76 nA	1 kΩ	50 + 0.2	100Ω	50 + 2

*0°C to 18°C and 28°C to 50°C

MAXIMUM LEAD RESISTANCE

Mode	Leads	Range	Maximum Lead Resistance
4-wire	Source	10 – 100Ω	10Ω
4-wire	Source	1 kΩ	100Ω
4-wire	Source	10 kΩ – 100 MΩ	1 kΩ
4-wire	Source	All	1 kΩ
2-wire	Source	All	Less than 0.001% of range unless offset

OPEN CIRCUIT VOLTAGE

Range	Voltage	Configuration
10Ω to 100 kΩ	7 volts max	4 Terminal
1 MΩ to 100 MΩ	25 volts max	2 Terminal

OVERLOAD

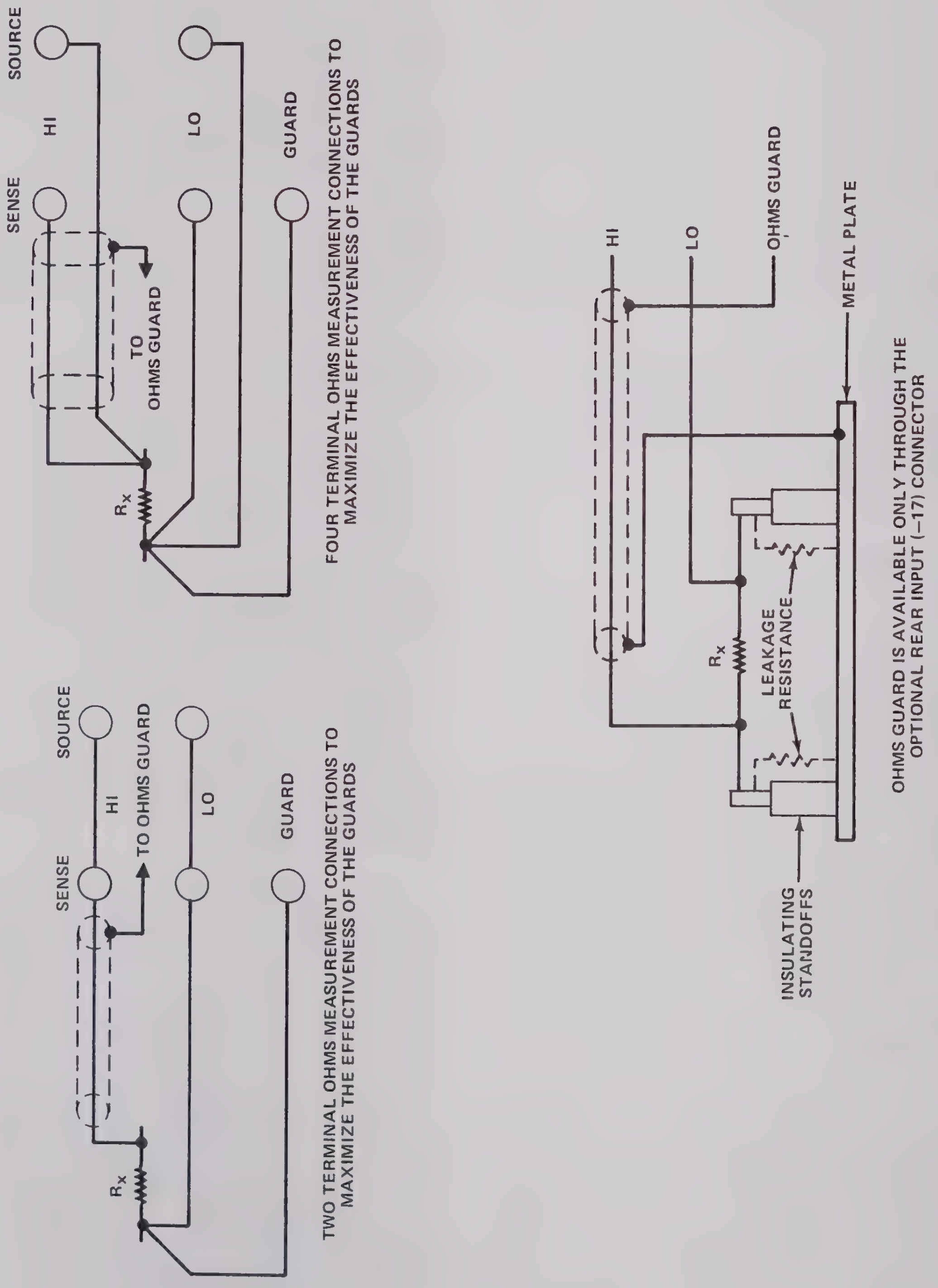
± 400V dc to 60 Hz, or 560 volts peak ac above 60 Hz maximum continuous on any range with no damage.

SETTLING TIME – (To Rated Accuracy)

80 ms, Fast Filter
800 ms, Slow Filter

DIGITIZING TIME

Mode of Operation	Filter	60 Hz		50 Hz	
		Approx. Rdg. Rate	Digitizing Time	Approx. Rdg. Rate	Digitizing Time
Bench	Fast	4 rdg/s	250 ms	3-1/3 rdg/s	300 ms
	Fast	1-1/2 rdg/s	700 ms	1-1/4 rdg/s	800 ms
	Slow	1-1/4 rdg/s	800 ms	1 rdg	1000 ms
	Slow	5/6 rdg	1200 ms	3/4 rdg	1450 ms
Remote	Fast	4 samples/rdg	145 ms	4 samples/rdg	175 ms
	Slow	4 samples/rdg	700 ms	4 samples/rdg	840 ms
(Subtract for fast Ohms)	Fast	–	110 ms	–	–
	Slow	–	560 ms	–	–


SENSE
SOURCE
HI
LO
GUARD
TO OHMS GUARD
R_X
SENSE
SOURCE
HI
LO
GUARD
TO OHMS GUARD
R_X
HI
LO
OHMS GUARD
METAL PLATE
R_X
LEAKAGE RESISTANCE
INSULATING STANDOFFS

TWO TERMINAL OHMS MEASUREMENT CONNECTIONS TO MAXIMIZE THE EFFECTIVENESS OF THE GUARDS

FOUR TERMINAL OHMS MEASUREMENT CONNECTIONS TO MAXIMIZE THE EFFECTIVENESS OF THE GUARDS

OHMS GUARD IS AVAILABLE ONLY THROUGH THE OPTIONAL REAR INPUT (−17) CONNECTOR

Figure 602-1. Ohms Measurement Connections And Guarding

602-9. For the two-wire ohms mode, the instrument should be zeroed with a good quality short between Sense-Source HI and Sense-Source LO. Select either autoranging or the 10Ω range manually. Depress the STORE switch. Depress the V DC/Ω ZERO switch. All ranges are now automatically zeroed. Ohms zero cannot be recalled. Depressing the RECALL switch while in Ohms results in a display of ERROR 0, then a return to the program. To compensate for lead resistance use the Offset mode. Short the ends of the leads together. Depress the STORE switch, then the OFFSET switch. This enters the lead resistance value into memory. Depress the OFFSET switch again (OFFSET LED illuminated) to enter the Offset mode in which the value of lead resistance will automatically be subtracted from further readings.

602-10. In the four-wire ohms mode, the instrument should be zeroed by placing a good quality short at the ends of the leads. Depress the V DC/Ω ZERO switch to enter the zero value, which will automatically be subtracted from further readings.

602-11. Guarding

602-12. The ohms guard connection is available only through the optional Rear Input Connection (–17). Figure 602-1 shows optimal use of the guard. Basically the ohms guard is used to minimize leakage resistance between the HI and LO leads which would appear as shunt resistance across high R_x values. In some high-resistance measurement set-ups, leakage resistance in or on the surface of insulating materials may provide enough shunt resistance to degrade the accuracy of the measurement. Figure 602-1 illustrates one such case. Connecting the ohms guard to the metal plate on which the standoffs are mounted reduces the effect of leakage resistance through or on the standoffs.

602-13. THEORY OF OPERATION

602-14. The function of the Ohms Converter is to produce a current through an unknown resistance such that the voltage across the unknown is proportional to the value of resistance. This is accomplished by configuring the unknown resistance, R_x, as the feedback element of an operational amplifier. A reference voltage, V_{REF}, is applied through a reference resistor, R_{REF}, to the summing node of the amplifier. By definition of an ideal operational amplifier, the current through R_x is the same current flowing through R_{REF} (the summing node represents a virtual ground). Figure 602-2 is a simplified schematic of the Ohms Converter and contains an illustration of the derivation of the formula for R_x. The current flowing through R_{REF} equals $(V_1 - V_2)/R_{REF}$. Using the expression for current to obtain the value of R_x:

$$R_x = R_{REF}\left(\frac{V_o}{V_1 - V_2}\right).$$

The Ohms Converter multiplexes the voltages which, after being routed through the DC Signal Conditioner and the Filter module, are measured by the A/D Converter.

602-15. The current reference for the Ohms Converter is derived from the –7V reference (RT4) from the A/D Converter. U4 is an inverting amplifier with two possible feedback paths to produce either approximately +2.3V or +18.5V as V_1. U4 drives Q8 with Q8 serving as a larger current source than is available from U4. R41, R45, and R56 are the reference resistors, each having an adjustment.

602-16. R_x is the feedback element for the operational amplifier composed of Q9 and U5. U5 drives Q37 which serves as a higher current source. This arrangement also allows a larger output voltage swing. Note that Q9 and U5 are configured as an inverter, yet the output of U5 is a positive voltage. Q37 draws its emitter current through R48 and R49 from the –30V supply with CR18 and CR13 ensuring that Q37 need not be in a state of saturation. SOURCE voltages out are negative voltages at SOURCE LO with respect to circuit common. In the 100M range, the voltage applied to R41 is divided by 8. However, the unattenuated V_{REF} is measured. The factor of 8 is preserved by assigning R_{REF} the value of 8 x R41 (32.768 MΩ) in the equation. As the Ohms Converter downranges, R41 remains enabled so lower R_{REF} values are actually parallel combinations. V_2 is not measured in the three highest ranges (1M, 10M, 100M) since lead resistance will not be large enough to affect accuracy.

602-17. Extensive overvoltage protection has been provided for the Ohms Converter. Refer to the full schematic. Voltages appearing on the SENSE or SOURCE HI terminals in excess of +28V or –3V (with respect to circuit common) are clamped to ground by Q14, CR7, Q10, and Q39. U5 is configured as a voltage comparator biased by CR19 and R14. The clamping action of Q14 or Q10 causes a voltage on the input Lo line which triggers comparator U5 through Q11 or Q15. In either case the output at U5 pin 7 toggles to its maximum positive level, clocking U3 while placing a high on the ID3 line. This opens relay K1 and removes the input voltages from the module. The high from U5 also inhibits the ACK logic so an Error 4 will be displayed. CR13 and CR14 at the output of Q9, U5 are high voltage blocking diodes. E1 is a spark gap preventing voltages in excess of 400V between the guard shield and circuit common.

602-18. The Ohms Converter is addressed by IC1, 2, 3 high, and must be addressed for each sample voltage. Samples are multiplexed out at the rate of one every four msec. This requires the fastest response time in the DC Signal Conditioner of any measurement mode.

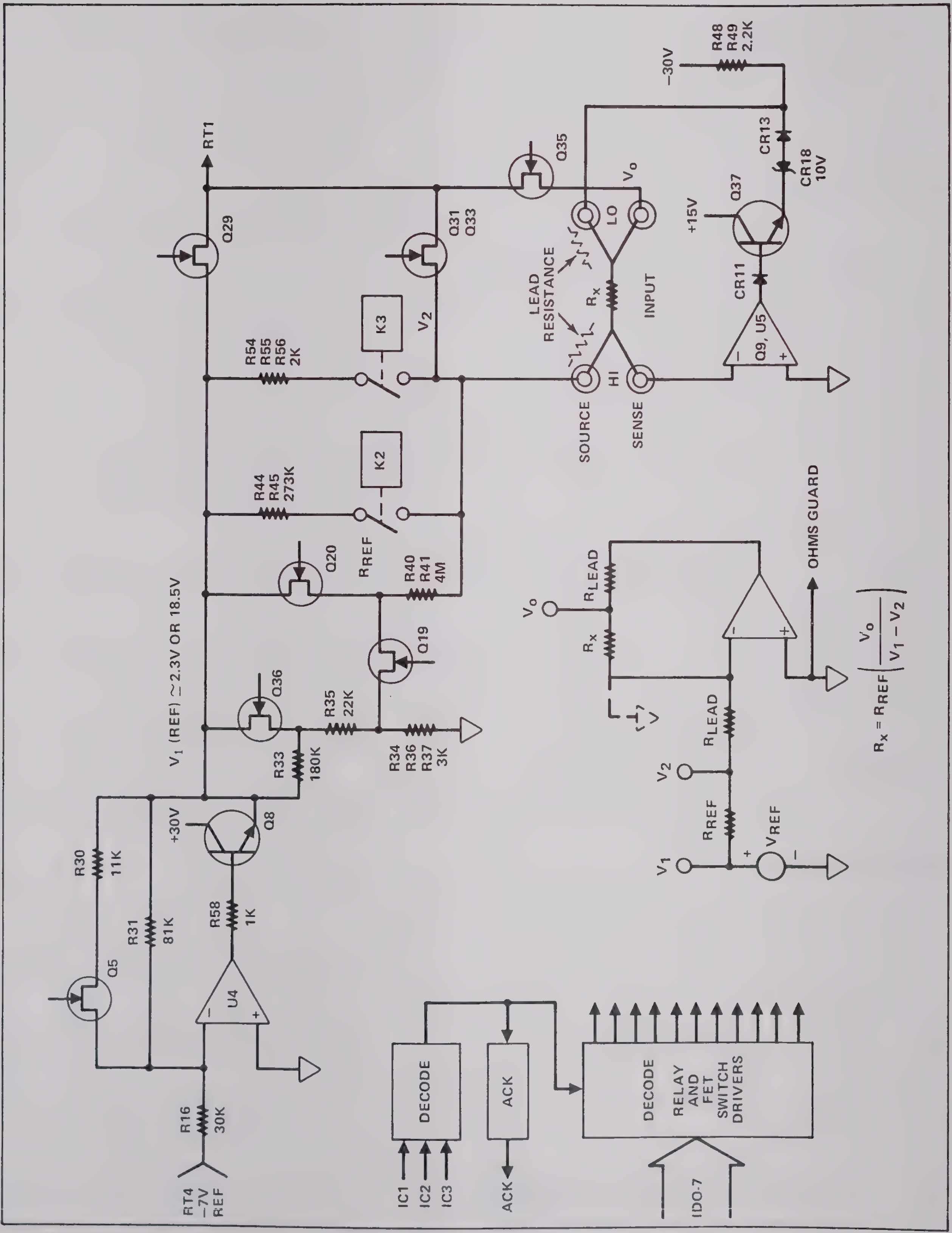

RT4
−7V
REF
R16
30K
U4
Q5
R30
11K
R31
81K
R58
1K
+30V
Q8
R33
180K
V1 (REF) ≃ 2.3V OR 18.5V
Q36
R35
22K
R34
R36
R37
3K
Q19
Q20
RREF
R40
R41
4M
R44
R45
273K
K2
R54
R55
R56
2K
K3
V2
Q29
RT1
Q31
Q33
Q35
Vo
LEAD
RESISTANCE
LO
HI
Rx
INPUT
SOURCE
SENSE
Q9, U5
CR11
Q37
+15V
CR18
10V
CR13
−30V
R48
R49
2.2K
Vo
RLEAD
Rx
OHMS GUARD
RLEAD
V2
RREF
V1
VREF
Rx = RREF (Vo / (V1 − V2))
IC1
IC2
IC3
DECODE
ACK
ACK
DECODE
RELAY
AND
FET
SWITCH
DRIVERS
IDO-7

Figure 602-2. Ohms Converter

602-19. MAINTENANCE

602-20. Performance Test

602-21. Test the Ohms function using the following procedure:

1. Connect test leads to the instrument in the four-wire configuration.
2. Select the Ohms function and Autoranging.
3. Short the HI and LO Ω SOURCE leads, short the HI and LO SENSE leads; then connect the two pairs of shorted leads together.
4. Zero the instrument by depressing the STORE switch, then the V DC/Ω ZERO switch.
5. Remove the shorts and sequentially connect the standard resistors in Table 602-2. The 8500A readings should fall within the limits specified.

Table 602-2. Performance Test

Standard Resistor	8500A Reading	
	Low (exponent)	High (exponent)
10	9.9975	10.0025
100	99.995	100.005
1K	.99996 (+3)	1.00004 (+3)
10K	9.9996 (+3)	10.0004 (+3)
100K	99.996 (+3)	100.004 (+3)
1M	.99996 (+6)	1.00004 (+6)
10M	9.9979 (+6)	10.0021 (+6)
100M	99.949 (+6)	100.051 (+6)

602-22. Calibration

602-23. Use the following procedure to calibrate the Ohms Converter:

1. Remove power and remove the Calibration Memory if installed.
2. Reapply power and allow a two hour warm-up.
3. Ensure that the dc Volts accuracy is within tolerance.
4. Short the HI and LO AMPS/Ω SOURCE terminals, short the HI, LO and GUARD VOLTS/Ω SENSE terminals, then short the two HI terminals. Use the terminal shorting links provided with the instrument and/or equivalents.
5. Use manual range selection to prevent range changes while testing at the range extremities.
6. Select the 10Ω range on the DMM.
7. Adjust R24 for a reading between -0.0003 and +0.0003.
8. Step through the other seven ranges, checking that the reading is 0 ± 1 digit on all seven ranges.
9. Remove the shorting links and make four-wire ohms measurement connections to the INPUT terminals. Select the 1MΩ range and connect the input leads to a 4 MΩ standard resistor.

NOTE

Refer to Table 4-1 of the Instruction Manual for specifications on the Standard Resistors.

10. Adjust R40 for a reading between 3.99998 (+6) and 4.00002 (+6).
11. Select the 100 MΩ range and connect the input leads to a 100 MΩ standard resistor.
12. Adjust R37 for a reading between 99.995 (+6) and 100.005 (+6).
13. Select the 100 kΩ range and connect the input leads to a 250 kΩ standard resistor.
14. Adjust R44 for a reading between 249.998 (+3) and 250.002 (+3).
15. Select the 1 kΩ range and connect the input leads to a 1.9 kΩ standard resistor.
16. Adjust R54 for a reading between 1.89998 (+3) and 1.90002 (+3).
17. Select the 10Ω range and short the four-terminal leads for a zero input.
18. Perform the Ohms Zero procedure found in the operating instructions, ensuring the result is 0.0000 ± 1 digit.
19. Perform the tests in Table 602-3. There are no adjustments for the readings, if any reading exceeds the listed tolerance the module is not acceptable.

Table 602-3. Calibration Tests

Resistance Standard	Readings		
	Minimum	Nominal	Maximum
10	9.9989	10.0000	10.0011
100	99.997	100.000	100.003
1k	0.99997 (+3)	1.00000 (+3)	1.00003 (+3)
10k	9.9997 (+3)	10.0000 (+3)	10.0003 (+3)
100k	99.997 (+3)	100.000 (+3)	100.003 (+3)
1M	0.99997 (+6)	1.00000 (+6)	1.00003 (+6)
10M	9.9989 (+6)	10.0000 (+6)	10.0011 (+6)
100M	99.969 (+6)	100.000 (+6)	100.031 (+6)

602-24. TROUBLESHOOTING

602-25. Troubleshooting procedures for the Ohms Converter follow the format used for the mainframe instrument. Table 602-4, Failure Isolation, assures that the problem is in the Ohms Converter. Table 602-5 lists symptoms and possible failures in the order of probability. Figure 602-3 shows timing relationships, while Tables 602-6 through 602-8 give additional troubleshooting information.

602-26. Always remove power before removing or installing modules. RT1 is available only in the front four option slots and not in the Isolator or Interconnect slot.

602-27. PARTS LIST

602-28. Table 602-9 is a parts breakdown for the Ohms Converter. Refer to Section 5 of this manual for ordering and use code information.

Table 602-4. Failure Isolation

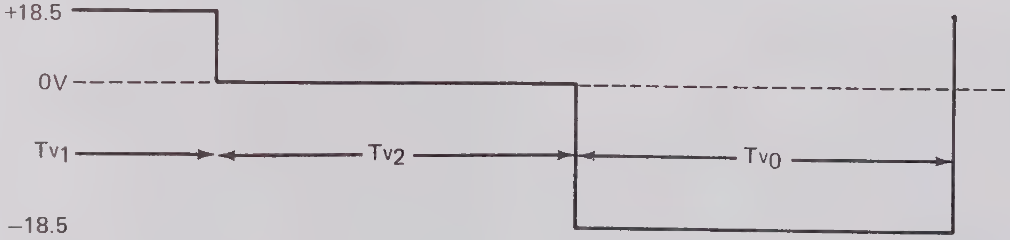
STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Perform DC Volts test (Section 4). Is DC Volts within tolerance?	2	Section 4
2	Perform Ohms test. Is Ohms within tolerance?	Section 4	3
3	Remove all optional modules except Isolator and Ohms converter.		
4	Is Ohms now within tolerance?	5	6
5	An optional module is affecting Ohms. Replace one at a time until Ohms goes bad. Last one in is faulty – go to appropriate portion of Section 6.		
6	Is Isolator installed?	7	9
7	Remove Isolator. Insert Jumper/Monitor pcb. Is Ohms within tolerance:	8	9
8	Bad Isolator. Go to Subsection 608.		
9	Check power supply voltages as follows. Test DMM LO on AR (analog return). VA1 = +14.25 to 15.75V VA2 = –14.25 to –15.75V VA3 = +29 to 32V VA4 = –29 to –32V Vcc = –15V, Vss = –20V: Difference = 4.9 to 5.2 RT4 = –6.993 to –7.007		
10	Are the supply voltages within tolerance?	11	Section 4
11	The problem is probably in the Ohms board. However, the DC Signal Conditioner may contribute errors if the slew rates of the amplifiers are not fast enough. Go to Table 602-5.		

Table 602-5. Symptom Analysis

SYMPTOM	POSSIBLE FAILURE
No Ohms Readings (V_0)	U5, Q9, Q35, Digital Logic
(V_1)	U4, Q8, Q29 Digital Logic & Drivers
Ohms Zero Drift	U5, Q9
10K – 100K Ranges Bad	Q32, Q33, Digital
10 – 100 – 1K Ranges Bad	Q30, Q31, Digital
10M Full Scale Low	Q20, Q22
No ACK	U5, Q14, Q11, Q38
All Ranges Out of Tolerance	Q37, U5
100M Noisy, 30M High	Q10, K3 Shorted
1K, 100K, 10M, 100M Ranges Bad	Q5, Q4
100M Range Bad	Q20, Q22, Q19 Leaky
Display Error 4 with no voltage at input	Q14
Noisy at 30M or Full Scale	CR15, CR17, CR4, CR8
Full Scale 1M, 10M, 100M Ranges Out of Tolerance	CR18
DC SIGNAL CONDITIONER	
Slew Rates Bad	Q37, Q38, Q19, U3, U5, U6

Note: If Q9, Q19, U5, R19, R20, R21, R23, R25, or R26 are replaced it is necessary to return the module to the factory (Attn: Parts) for temperature compensation.

Voltages shown are at RT6, (DC Signal Conditioner Output).



Vo is proportional to Rx, Vo for full scale Rx is shown.

Sample Rate	Filter	Tv_1	Tv_2 *	Tv_0
Fast	No	30ms	30ms	200 ms
Fast	Yes	30ms	30ms	650ms
Slow	No	30ms	30ms	600ms
Slow	Yes	30ms	30ms	1060ms

These are approximate times.

*Except Tv_2 for ranges 1M, 10M, 100M is zero. No V_2 is measured for these ranges.

The first reading after a range change or overrange is modified with longer V_1 and V_2 periods.

Figure 602-3. Timing

Table 602-6. Voltage Measurements

Range	Full Scale	V* TP2	R ref	I ref* (Source HI)	V_0* (Range Value)	V_1* (TP2)	V_2 (Offset)
10	31.25	+18.5V	2K	9.3ma	.093V	+18.5	< 100mv
100	250	+18.5V	2K	9.3ma	.93V	+18.5	< 100mv
1000	2000	+2.3V	2K	1.2ma	1.2V	+2.3	< 100mv
10K	32K	+18.5V	256K	72μa	.72V	+18.5	< 100mv
100K	256K	+2.3V	256K	9μa	.9V	+2.3	< 100mv
1M	4.091M	+18.5V	4.091M	4.5μa	4.5V	+18.5	NA
10M	32.728M	+2.3V	4.091M	.56μa	5.6V	+2.3	NA
100M	261.824M	+2.3V/8	4.091M	70na	7V	+2.3	NA

* Approximate values (± 5%)

TP1 is always −7.0V
TP3 Ref common (use for low side of measurements)
TP4 amplifier offset (<10μv properly adjusted)
V_0 is proportional to RX
V_2 will vary some with range change

SCANNER: Voltages will appear on RT1 in order. $V_0 - V_1 - V_2$

Table 602-7. Range Switch Closures

0 = Switch Open

1 = Switch Closed

Chart applies for time the particular voltage is SCANNED. All other times "0" applies.

	K1	K2	K3	Q5	Q19	Q20	V_0 Q29	V_{2a} Q31	V_{2b} Q33	V_1 Q35
10Ω	1	0	1	0	0	1	1	1	0	1
100Ω	1	0	1	0	0	1	1	1	0	1
1KΩ	1	0	1	1	0	1	1	1	0	1
10KΩ	1	1	0	0	0	1	1	0	1	1
100KΩ	1	1	0	1	0	1	1	0	1	1
1MΩ	1	0	0	0	0	1	1	0	0	1
10MΩ	1	0	0	1	0	1	1	0	0	1
100MΩ	1	0	0	1	1	0	1	0	0	1
OHMS	0	0	0	1	0	1	0	0	0	0

Table 602-8. Address and Data Coding

ADDRESS IC1, 2, 3 HIGH									
Range	V	ID0	ID1	ID2	ID3	ID4	ID5	ID6	ID7
10	V_0	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
100	V_0	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
1K	V_0	0	1	1	0	1	1	1	0
	V_1	1	0	1	0	1	1	1	0
	V_2	1	1	0	0	1	1	1	0
10K	V_0	0	1	1	0	0	0	1	1
	V_1	1	0	1	0	0	0	1	1
	V_2	1	1	0	0	0	0	1	1
100K	V_0	0	1	1	0	1	0	1	1
	V_1	1	0	1	0	1	0	1	1
	V_2	1	1	0	0	1	0	1	1
1M	V_0	0	1	1	0	0	1	1	1
	V_1	1	0	1	0	0	1	1	1
10M	V_0	0	1	1	0	1	1	1	1
	V_1	1	0	1	0	1	1	1	1
100M	V_0	0	1	1	0	1	1	0	1
	V_1	1	0	1	0	1	1	0	1
OHMS		1	1	1	1	1	1	1	1

Table 602-9. Ohms Converter PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-02	⊗OHMS CONVERTER PCB ASSEMBLY FIGURE 602-4 (MIS-4110T)	ORDER	BY	OPTION -02			
C1	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	4		
C2	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C3	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C4	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C5	CAP, CER, 33 PF +/-2%, 100V	354852	80031	2222-638-10339	1		
C6	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	2		
C7	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	REF		
C8	CAP, POLYSTRYRN, 100 PF +/-10%, 500V	446609	89536	446609	1		
C9	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	7		
C10	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C11	CAP, TA, 22 UF +/-20%, 15V	423012	56289	196D226X0015KA1	1		
C12	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C13	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C14	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C15	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C16	CAP, TA, 5.6 UF +/-20%, 25V	368869	56289	196D565X0025KA1	1		
C17	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	3		
C18	CAP, TA, 0.47 UF +/-20%, 35V	161349	56289	196D474X0035HA1	1		
C19	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C20	CAP, CER, 0.0022 UF +/-10%, 500V	268425	32897	851000Z5R222K	1		
C21	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C22	CAP, TA, 0.33 UF +/-20%, 35V	408690	56289	196D334X0035HA1	1		
C23	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
CR1	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	6	2	
CR2	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, SI, RECT	428144	01295	1N4006	7	2	
CR7	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR8	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR9	DIODE, ZENER, UNCOMP	113324	07910	1N961A	2	1	
CR10	DIODE, SI, MULTIPELLET	375485	09214	MPD300	2	1	
CR11	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR12	DIODE, SI, MULTIPELLET	375485	09214	MPD300	REF		
CR13	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR14	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR15	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR16	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR17	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR18	DIODE, ZENER, UNCOMP	113324	07910	1N961A	REF		
CR19	DIODE, 2-PELLET	375477	09214	MPD200	1	1	
CR20	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
E1	SURGE PROTECTOR, VOL	442723	25088	B1-C145	1		
H1	SCREW, PHP, 4-40 X 5/8	413062	89536	413062	1		
K1	RELAY, ARMATURE	515429	89536	515429	1		
K2	RELAY, DRY REED	357582	71707	UF40070	2		
K3	RELAY, DRY REED	357582	71707	UF40070	REF		
L1	CHOKE, RF	111542	99800	1537-76	1		

Table 602-9. Ohms Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP1	CASE ASSY (INCLUDES MP2-MP9)	458927	89536	458927	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411942	89536	411942	REF		
MP6	DECAL, OHMS CONVERTER	413435	89536	413435	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP11	SPACER, XSTR	152207	07047	10123-DAP	5		
MP12	SOCKET, COMPONENT LEAD (NOT SHOWN) (W/R20,R21,R23,R26)	343285	00779	2-331272-6	8		
MP13	LUG, SOLDER	103531	77963	501	1		
MP14	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	1		
Q1	XSTR, SI, NPN	226290	04713	MPS3640	1	1	
Q2	XSTR, SI, NPN	218396	04713	2N3904	14	3	
Q3	XSTR, SI, PNP	195974	04713	2N3906	7	2	
Q4	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q5	XSTR, FET, N-CHANNEL	261578	89536	261578	4	1	
Q6	XSTR, SI, PNP	168716	07263	S19254	3	1	
Q7	XSTR, SI, PNP	168716	07263	S19254	REF		
Q8	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q9	XSTR, FET, DUAL, N-CHANNEL	476309	89536	476309	1	1	
Q10	XSTR, SI, NPN	203489	09214	11C2322	5	1	
Q11	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q12	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q13	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q14	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q15	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q16	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q17	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q18	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q19	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q20	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q21	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q22	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q23	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q24	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q25	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q26	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q27	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q28	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q29	XSTR, FET, N-CHANNEL	393314	89536	393314	4	1	
Q30	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q31	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q32	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q33	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q34	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q35	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q36	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		

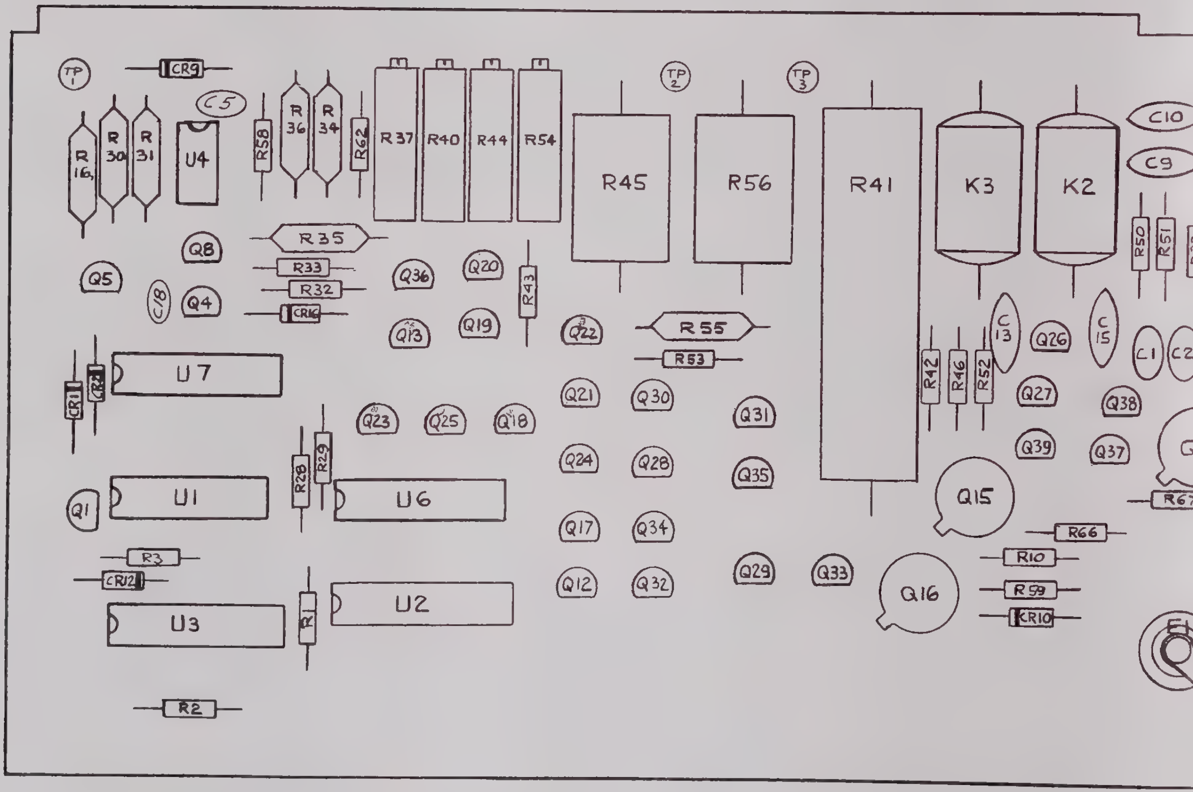
Table 602-9. Ohms Converter PCB Assembly (cont)

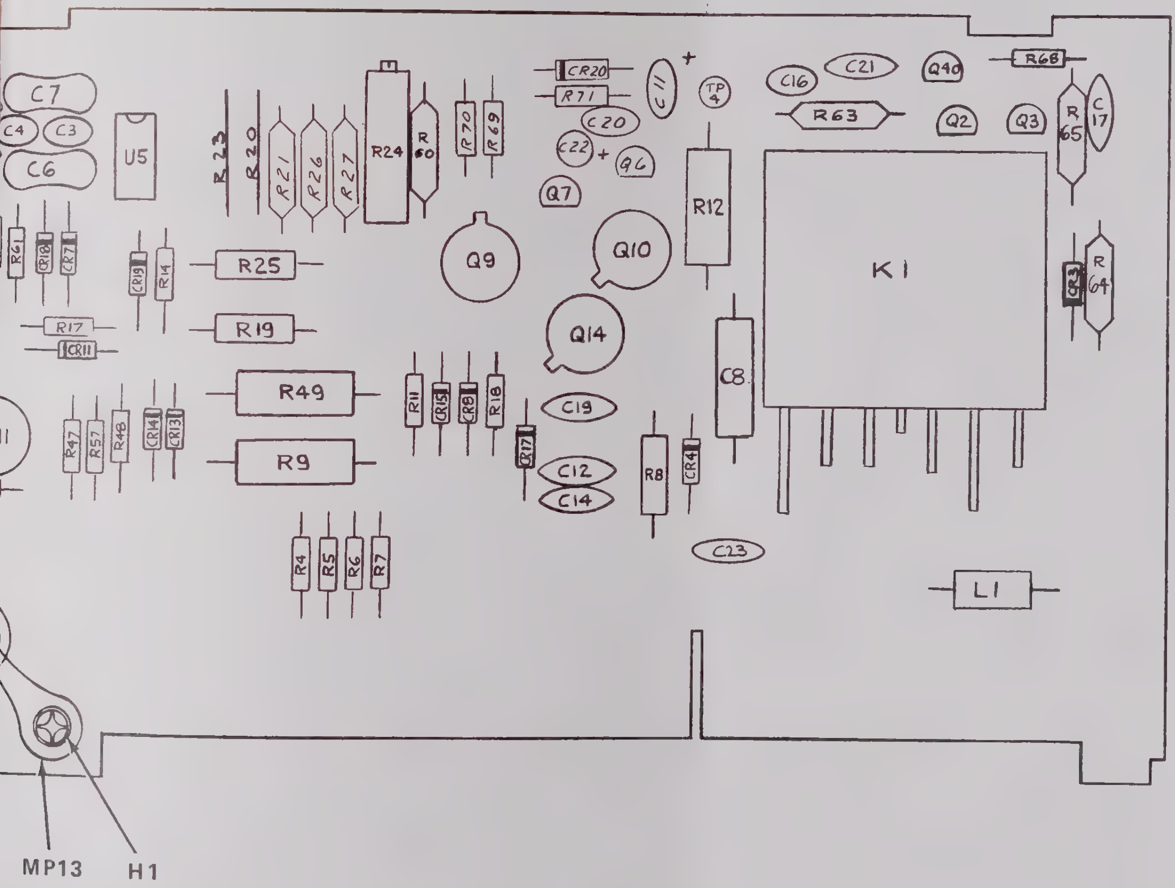
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q38	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q39	XSTR, SI, PNP	168716	07263	S19254	REF		
Q40	XSTR, FET JUNCTION, N-CHANNEL	288324	89536	288324	1	1	
R1	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	7		
R2	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	6		
R3	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R4	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R5	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R6	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R7	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R8	RES, COMP, 220K +/-5%, 1/2W	109025	01121	EB2245	1		
R9	RES, COMP, 1.8K +/-5%, 1W	180331	01121	GB1825	2		
R10	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R11	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R12	RES, COMP, 100K +/-5%, 1W	109397	01121	GB1041	1		
R14	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R16	RES, MTL. FILM, 30.1K +/-1%, 1/8W	293431	91637	MFF1-83012F	1		
R17	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	6		
R18	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R19	RES, WW, 40K +/-0.1%	271403	89536	271403	2		
R20	RES, SELECTED				1		
R21	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	2		
R23	RES, SELECTED				REF		
R24	RES, VAR, CERMET, 100 +/-20%, 1/2W	267823	11236	190PC101B	1		
R25	RES, WW, 40K +/-0.1%	271403	89536	271403	REF		
R26	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	REF		
R27	RES, MTL. FILM, 20K +/-1%, 1/8W	291872	91637	MFF1-82002F	1		
R28	RES, DEP. CAR, 39K +/-5%, 1/4W	442400	80031	CR251-4-5P39K	2		
R29	RES, DEP. CAR, 39K +/-5%, 1/4W	442400	80031	CR251-4-5P39K	REF		
R30	RES, MTL. FILM, 11.3K +/-1%, 1/8W	335414	91637	MFF1-81132F	1		
R31	RES, MTL. FILM, 80.6K +/-1%, 1/8W	312710	91637	MFF1-88062F	1		
R32	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R33	RES, DEP. CAR, 180K +/-5%, 1/4W	348946	80031	CR251-4-5P180K	1		
R34	RES, MTL. FILM, 3.16K +/-0.1%, 1/8W	340588	91637	MFF1-83161B	1		
R35	RES, MTL. FILM, 21.5K +/-0.1%, 1/8W	344440	91637	MFF1-82152B	1		
R36	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	MFF1-81003F	1		
R37	RES, VAR, CERMET, 50K +/-10%, 1/2W	330688	11236	190PC503B	1		
R39	RES, DEP. CAR, 1.6K +/-5%, 1/4W	348805	80031	CR251-4-5P1K6	1		
R40	RES, VAR, CERMET, 10K +/-10%, 1/2W	267880	11236	190PC103B	1		
R41	RES, WW, 4.091M +/-0.1%, 2W	412205	89536	412205	1		
R42	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R43	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R44	RES, VAR, CERMET, 500 +/-20%, 1/2W	267849	11236	190PC501B	1		
R45	RES, WW, 272.84K +/-0.08%, 1/2W	412197	89536	412197	1		
R46	RES, DEP. CAR, 3.3K +/-5%, 1/4W	348813	80031	CR251-4-5P3K3	1		
R47	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	4		
R48	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	2		
R49	RES, COMP, 1.8K +/-5%, 1W	180331	01121	GB1825	REF		
R50	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	2		
R51	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	REF		

Table 602-9. Ohms Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R52	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R53	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R54	RES, VAR, CERMET, 200K +/-20%, 1/2W	381509	11236	190PC204B	1		
R55	RES, MTL. FILM, 332K +/-1%, 1/8W	289504	91637	MFF1-83323F	1		
R56	RES, WW, 2.01K +/-0.1%, 1/2W	412189	89536	412189	1		
R57	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R58	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	2		
R59	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R60	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	MFF1-81004F	1		
R61	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R62	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R63	RES, MTL. FILM, 15.8K +/-1%, 1/8W	293688	91637	MFF1-81582F	1		
R64	RES, MTL. FILM, 73.2K +/-1%, 1/8W	237222	91637	MFF1-87322D	1		
R65	RES, MTL. FILM, 30.1K +/-1%, 1/8W	168286	91637	MFF1-83012F	1		
R66	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R67	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R68	RES, DEP. CAR, 560K +/-5%, 1/4W	342642	80031	CR251-4-5P560K	1		
R69	RES, DEP. CAR, 300 +/-5%, 1/4W	441519	80031	CR251-4-5P300E	1		
R70	RES, DEP. CAR, 200K +/-5%, 1/4W	441485	80031	CR251-4-5P200K	1		
R71	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	REF		
U1	⊗IC, C-MOS, NAND GATES	375147	02735	CD4023AE	1	1	
U2	⊗IC, C-MOS, QUAD, CLOCKED "D" LATCH	355149	02735	CD4042AE	2	1	
U3	⊗IC, C-MOS, QUAD, CLOCKED "D" LATCH	355149	02735	CD4042AE	REF		
U4	IC, LIN, OPNL AMPL	363515	34333	SG301A	1	1	
U5	IC, LIN, OPNL AMPL	418566	12040	LM358N	1	1	
U6	IC, RES NETWORK	380618	89536	380618	2	1	
U7	IC, RES NETWORK	380618	89536	380618	REF		

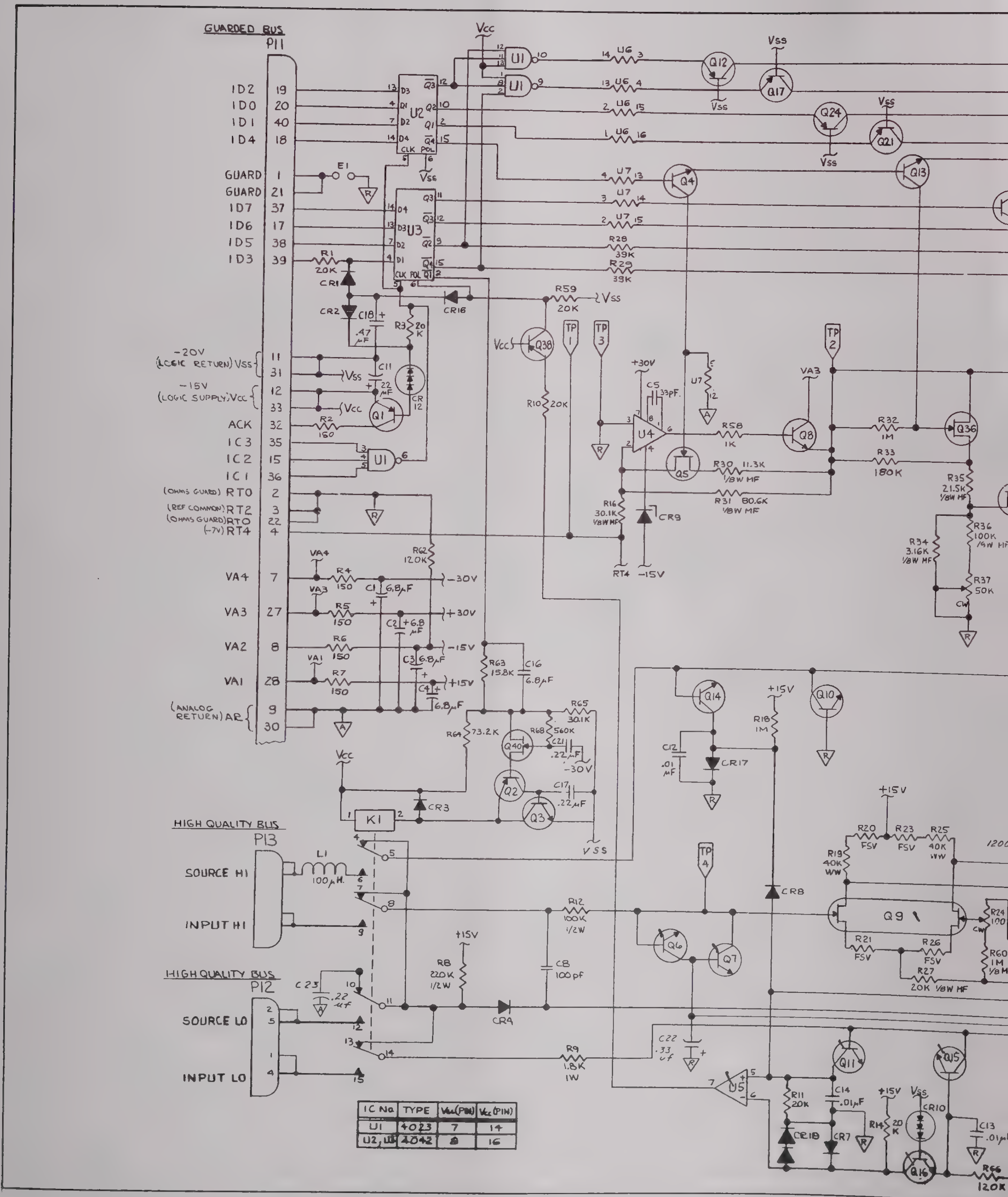
1 SEE TABLE 5-17 AT THE END OF SECTION 5.


TP 1
CR9
C5
R 16
R 30
R 31
U4
R58
R 36
R 34
R62
R37
R40
R44
R54
TP 2
TP 3
R45
R56
R41
K3
K2
C10
C9
R50
R51
R35
Q8
R33
R32
CR16
Q5
C18
Q4
Q36
Q20
R43
Q13
Q19
Q22
R 55
R53
C 13
Q26
C 15
C1
C2
R42
R46
R52
U 7
CR1
CR4
Q21
Q30
Q31
Q27
Q38
Q23
Q25
Q18
R29
R28
Q24
Q28
Q35
Q39
Q37
Q1
U1
U6
Q15
R67
Q17
Q34
R66
R3
CR12
R10
Q12
Q32
Q29
Q33
Q16
R59
CR10
U3
R1
U2
R2

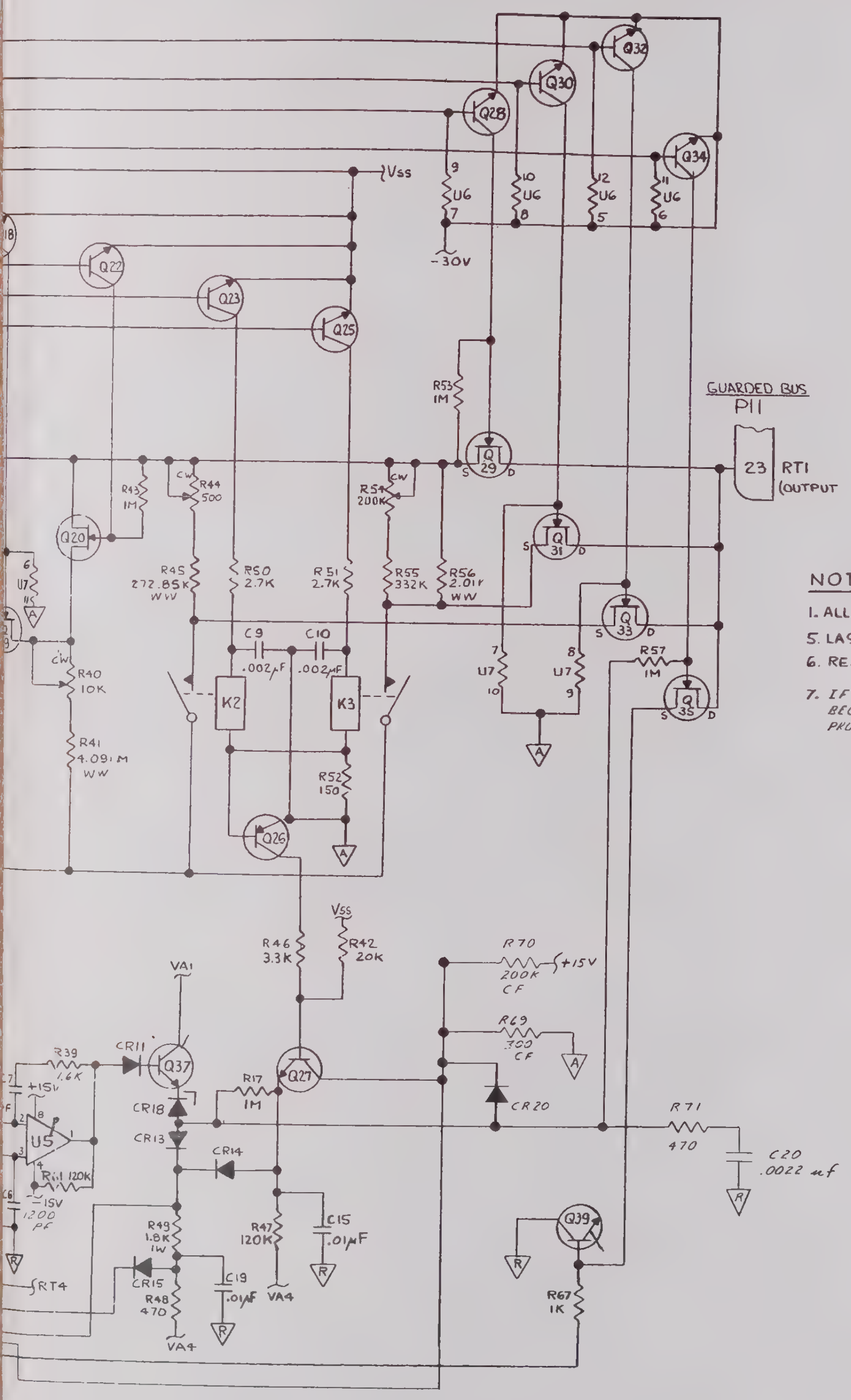

C7
C4
C3
C6
U5
R23
R20
R21
R26
R27
R24
R60
R70
R69
CR20
R71
C11
+
TP4
C16
C21
Q40
R68
R63
Q2
Q3
R65
C17
C20
C22
+
Q6
Q7
R12
R61
CR18
CR7
CR19
R14
R25
Q9
Q10
K1
CR3
R64
R17
CR11
R19
Q14
C8
R49
R47
R57
R48
CR14
CR13
R11
CR15
CR8
R18
C19
CR17
R9
C12
C14
R8
CR4
C23
R4
R5
R6
R7
L1
MP13
H1

MIS-1710

Figure 602-4. Ohms Converter PCB Assembly


GUARDED BUS
P11
ID2 19
ID0 20
ID1 40
ID4 18
GUARD 1
GUARD 21
ID7 37
ID6 17
ID5 38
ID3 39
-20V (LOGIC RETURN) VSS 11 31
-15V (LOGIC SUPPLY) VCC 12 33
ACK 32
IC3 35
IC2 15
IC1 36
(OHMS GUARD) RT0 2
(REF COMMON) RT2 3
(OHMS GUARD) RT0 22
(-7V) RT4 4
VA4 7
VA3 27
VA2 8
VA1 28
(ANALOG RETURN) AR 9 30
Vcc
U1
U2
U3
U6
U7
Q12
Q17
Q24
Q21
Q4
Q13
Vss
E1
R1 20K
CR1
CR2
C18 .47 µF
R3 20K
CR16
R59 20K
Vss
C11 22 µF
CR12
Q1
R2 150
Q38
TP 1
TP 3
TP 2
R10 20K
+30V
C5 33pF.
U4
Q5
R58 1K
Q8
VA3
R32 1M
Q36
R33 180K
R30 11.3K 1/8W MF
R31 80.6K 1/8W MF
R16 30.1K 1/8W MF
CR9
RT4 -15V
R35 21.5K 1/8W MF
R36 100K 1/8W MF
R34 3.16K 1/8W MF
R37 50K
CW
R28 39K
R29 39K
R62 120K
VA4
R4 150
C1 6.8µF
-30V
VA3
R5 150
C2 6.8 µF
+30V
R6 150
C3 6.8µF
-15V
VA1
R7 150
C4 6.8µF
+15V
R63 15.8K
C16 6.8µF
R65 30.1K
R64 73.2K
R68 560K
C21 .22µF
Q40
-30V
Q2
C17 .22µF
Q3
VSS
Vcc
CR3
K1
HIGH QUALITY BUS
P13
SOURCE HI
INPUT HI
L1 100µH.
HIGH QUALITY BUS
P12
SOURCE LO
INPUT LO
C23 .22 µf
+15V
R8 220K 1/2W
CR4
R12 100K 1/2W
C8 100pf
R9 1.8K 1W
TP 4
Q6
Q7
C22 .33 µf
Q14
C12 .01 µF
CR17
+15V
R18 1M
Q10
CR8
+15V
R20 FSV
R23 FSV
R25 40K WW
R19 40K WW
Q9
R24 100
R21 FSV
R26 FSV
R27 20K 1/8W MF
R60 1M 1/8W MF
1200
U5
R11 20K
CR18
C14 .01µF
CR7
Q11
+15V
Vss
R14 20K
CR10
Q15
Q16
C13 .01µF
R66 120K

IC No	TYPE	Vss(PIN)	Vcc(PIN)
U1	4023	7	14
U2, U3	4042	8	16


Q32
Q30
Q28
Q34
Vss
9
UG
7
10
UG
8
12
UG
5
11
UG
6
-30V
Q22
Q23
Q25
R53
1M
GUARDED BUS
P11
23
RT1
(OUTPUT
Q29
S
D
Q31
Q33
Q35
Q20
R43
1M
CW
R44
500
R54
200K
R45
272.85K
WW
R50
2.7K
R51
2.7K
R55
332K
R56
2.01r
WW
R57
1M
C9
.002μF
C10
.002μF
K2
K3
7
U7
10
8
U7
9
R40
10K
R41
4.091M
WW
R52
150
Q26
U7
U5
Vss
R46
3.3K
R42
20K
R70
200K
CF
+15V
R69
300
CF
VA1
CR11
Q37
R39
1.6K
+15V
Q27
R17
1M
CR18
CR20
CR13
U5
R11 120K
CR14
-15V
1200
PF
R71
470
C20
.0022 uf
R49
1.8K
1W
R47
120K
C15
.01μF
Q39
CR15
R48
470
VA4
C19
.01μF
VA4
R67
1K
RT4
VA4

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTORS 1/4W, CC, AND ALL RESISTANCE IN OHMS.

5. LAST REF. DES. No's USED: U7, Q40, CR20, K3, E1, R70, C22.

6. REF. DES. No'S NOT USED: CR5, CR6, R13, R15, R22, R38.

7. IF Q19, U5, R19, R20, R21, R23, R25 OR R26 ARE REPLACED, IT BECOMES NECESSARY TO TC THE MODULE PER MIS-4110-151 TEST PROCEDURE.

MIS-1110

Figure 602-4. Ohms Converter PCB Assembly (cont)

Option —03
Current Shunts

603-1. INTRODUCTION

603-2. Installation of the Current Shunts module allows current measurement in five ranges: 100 μA, 1mA, 10 mA, 100 mA, and 1 A. Range selection can be done in either the manual or autorange mode. Either dc or ac current measurements may be made, but ac measurements require installation of one of the optional ac converters.

CAUTION

Selection of the autorange mode when using a constant current power source, e.g. the Fluke 3330B Constant Current Mode, can result in excessive voltage overloads. The overload results from the momentary open circuit at the 8500A/8502A input terminals when ranging into or out of the 100 μA and 1A current ranges. Constant voltage power sources are not effected.

603-3. SPECIFICATIONS

603-4. Table 603-1 lists the specifications for the Current Shunts module. Accuracy specifications for the lower current ranges (100 μA, 1 mA, and 10 mA) depend on the source resistance of the current to be measured, due to the configuration of the measurement circuit. Source resistances only affect the number of floor digits, which can be determined from the formula given. For source resistances greater than specified, the number of uncertain digits will decrease. For ac currents, source resistance has a similar effect but the formula is much too complex for ordinary use.

603-5. INSTALLATION

603-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing the Current Shunts module. The interconnect diagram in Section 8 contains a table listing permissible and preferred slots.

603-7. OPERATING NOTES

603-8. Operation of the front panel switches is the same as described in Section 2 of this manual. Inputs to the Current Shunts module are between Source HI and Source LO. Sense HI and Sense LO may be left connected with the shorting links provided.

NOTE

Position sensitivity of switches requires that the instrument be operated within 30° of its horizontal position.

603-9. THEORY OF OPERATION

603-10. The function of the Current Shunt module is to generate a voltage proportional to the current to be measured. Outputs from the Current Shunt module are applied either to the DC Signal Conditioner for dc currents or to an optional ac converter for ac currents.

603-11. Two modes of operation are used in the Current Shunt module, depending on the range selected. Figure 603-1 illustrates the two configurations and contains tables relating resistors, switches, and relays to each range. Mode A is used for the 100 μA, 1 mA, and 10 mA ranges. Input currents are applied to the summing node (virtual ground) of an operational amplifier through R4. R4 ensures stability when the current source is highly capacitive, while presenting a very low voltage burden. The formula given for determining floor digits (uncertainty) in the accuracy specifications is based on the feedback resistors used in the three lowest ranges. For source resistances less than approximately 10 x $R_{FEEDBACK}$, the gain of the circuit becomes greater than one for error sources such as offset voltages and current noise. Thus the basic uncertainty (digits) of a measurement increases as the source resistance decreases. The output voltage is equal to the input current multiplied by $R_{FEEDBACK}$.

Table 603-1. Current Shunts Specifications

ACCURACY

(Refer to the specifications table in Section 1 for required environmental conditions)

DIRECT CURRENT

RANGE	FULL SCALE	AT SOURCE[1] RES. (R_s)	ACCURACY ±(% OF INPUT + NO. OF DIGITS[2])		
			24 HOURS	90 DAYS	1 YEAR
100 uA	312 uA	80 kΩ	0.02 + 10	0.03 + 10	0.05 + 10
1 mA	2.5 mA	10 kΩ	0.02 + 10	0.03 + 10	0.05 + 10
10 mA	20 mA	1.25 kΩ	0.02 + 10	0.03 + 10	0.05 + 10
100 mA	160 mA	40Ω	0.03 + 20	0.05 + 20	0.1 + 20
1 A	1.28A	10Ω	0.03 + 20	0.05 + 20	0.1 + 20

[1] *For Source Resistance less than specified, replace floor digit specification with following.*

Accuracy: Range	*+ No. of Digits*
100 uA	*9 (1 + 8k/R_S)*
1 mA	*9 (1 + 1k/R_S)*
10 mA	*9 (1 + 125/R_S)*

[2] *For high resolution multiply the number of digits by 10.*

ALTERNATING CURRENT

Range	Full Scale	Frequency	Accuracy ±(% of Input + No. of Digits) from 0.1% of full scale to full scale:					
			24 Hours		90 Days		1 Year	
			Average Current	True RMS Current	Average Current	True RMS Current	Average Current	True RMS Current
100 uA*	312.5 uA	10 Hz–20 Hz	–	0.7 + 110	–	1.0 + 110	–	2.0 + 110
		20 Hz–50 Hz	0.55 + 9	0.55 + 35	0.8 + 9	0.8 + 35	1.6 + 10	1.6 + 35
		50 Hz–10 kHz	0.3 + 9	0.28 + 35	0.4 + 9	0.4 + 35	0.8 + 10	0.8 + 35
		10 kHz–20 kHz	0.5 + 9	0.7 + 110	0.7 + 9	1.0 + 110	1.5 + 10	2.0 + 110
		20 kHz–50 kHz	1.0 + 9	1.0 + 260	1.5 + 9	1.5 + 260	3.0 + 10	3.0 + 260
		50 kHz–100 kHz	2.0 + 9	2.8 + 760	3.0 + 9	4.0 + 760	6.0 + 10	8.0 + 760
1 mA* and 10 mA*	2.5 mA 20 mA	10 Hz–20 Hz	–	0.7 + 110	–	1.0 + 110	–	2.0 + 110
		20 Hz–50 Hz	0.35 + 9	0.35 + 35	0.5 + 9	0.5 + 35	1.0 + 9	1.0 + 35
		50 Hz–10 kHz	0.05 + 9	0.08 + 35	0.06 + 9	0.11 + 35	0.12 + 9	0.22 + 35
		10 kHz–20 kHz	0.08 + 9	0.14 + 110	0.11 + 9	0.2 + 110	0.22 + 9	0.4 + 110
		20 kHz–50 kHz	0.08 + 9	0.2 + 260	0.12 + 9	0.3 + 260	0.24 + 9	0.6 + 260
		50 kHz–100 kHz	0.35 + 9	0.7 + 760	0.51 + 9	1.0 + 760	1.0 + 9	2.0 + 760
100 mA	160 mA	10 Hz–20 Hz	–	0.7 + 150	–	1.0 + 150	–	2.0 + 150
		20 Hz–50 Hz	0.34 + 55	0.35 + 80	0.5 + 55	0.5 + 80	1.0 + 55	1.0 + 80
		50 Hz–10 kHz	–	0.18 + 80	–	0.26 + 80	–	0.52 + 80
		50 Hz–100 kHz	0.16 + 55	–	0.24 + 55	–	0.5 + 55	–
1A	1.28A	10 Hz–20 Hz	–	0.7 + 150	–	1.0 + 160	–	2.0 + 160
		20 Hz–50 Hz	0.34 + 65	0.35 + 90	0.5 + 65	0.5 + 90	1.0 + 65	0.5 + 90
		50 Hz–10 kHz	0.16 + 65	0.18 + 90	0.24 + 65	0.26 + 90	0.5 + 65	0.52 + 90

**Minimum Source Resistance, same as for Direct Current.*

Table 603-1. Current Shunts Specifications (Continued)

OPERATING CHARACTERISTICS

DIRECT CURRENT

Range	Full Scale	At Source 1 Res. (R_s)	Temperature 2 Coefficient	
			Voltage Burden	± (ppm/rdg + No. of Digits)/°C 3
100 uA	312 uA	80 kΩ	≤100 mV	25 + 0.6
1 mA	2.5 mA	10 kΩ	≤100 mV	25 + 0.6
10 mA	20 mA	1.25 kΩ	≤200 mV	25 + 0.6
100 mA	160 mA	–	≤200 mV	35 + 0.6
1A	1.28A	–	≤500 mV	35 + 0.6

1 For Source Resistance less than specified, replace Temperature Coefficient with the following:

Temperature Coefficient:	*Range*	*+ No. of Digits/°C*
	100 uA	*0.5 (1 + 8k/R_s)*
	1 mA	*0.5 (1 + 1k/R_s)*
	10 mA	*0.5 (1 + 125/R_s)*

2 0°C to 18°C and 28 C to 50°C.

3 For high resolution multiply No. of digits by 10

OVERLOAD

1.5A maximum, ± 140V dc to 60 Hz, or 200V peak ac above 60 Hz on any range with no damage.

PROTECTION

1-1/2A fuse

SETTLING & DIGITIZING TIME

Same as dc volts

ALTERNATING CURRENT

TEMPERATURE COEFFICIENT (0°C to 18°C and 28°C to 50°C)

RANGE	TEMPERATURE COEFFICIENT	
	RMS AC	AVG. AC
100 uA*	(50 ppm + 3.5 digits(/°C	(40 ppm + 1.5 digits)/°C
1 mA*	(50 ppm + 3.5 digits(/°C	(40 ppm + 1.5 digits(/°C
10 mA*	(50 ppm + 3 digits)/°C	(40 ppm + 1 digit)/°C
100 mA	(50 ppm + 9 digits)/°C	(40 ppm + 7 digits)/°C
1A	(50 ppm + 9 digits)/°C	(40 ppm + 7 digits)/°C

VOLTAGE BURDEN

Same as dc current

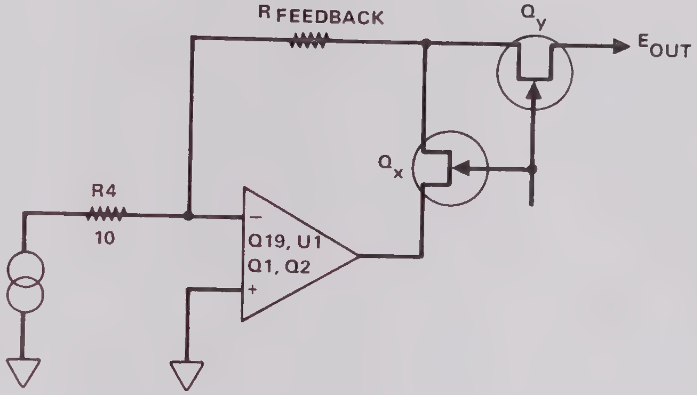
OVERLOAD

1.5A maximum current (1-1/2A fuse protected) ± 140V dc to 60 Hz, or 200V peak ac above 60 Hz on any range with no damage.

CREST FACTOR (RMS only)

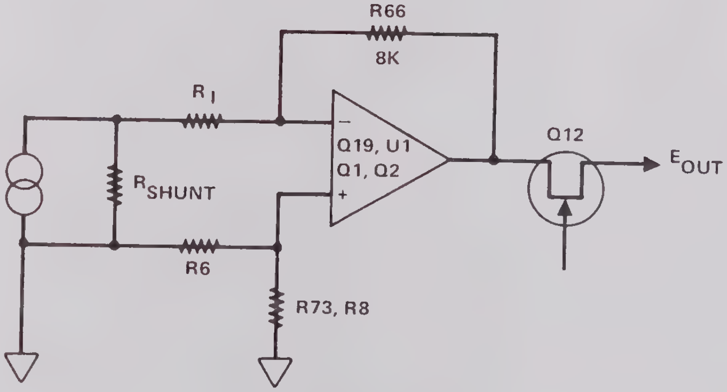
≤4.5 full scale, increasing down scale by:

$$4.5\sqrt{\frac{I_{Range}}{I_{Input}}}$$


R FEEDBACK
Q_y
E_{OUT}
Q_x
R4
10
–
Q19, U1
Q1, Q2
+

MODE A – 100 μA, 1 mA, 10 mA

RANGE	$R_{FEEDBACK}$	Q_X	Q_Y	RELAYS	FULL SCALE E_{OUT}
100 μA	R30, R31	Q30	Q31	K3, K4	.8 V
1 mA	R33, R34	Q7	Q10	K3, K4	1.0 V
10 mA	R36, R37	Q9	Q8	K3, K4	1.25 V


R66
8K
R_I
–
Q19, U1
Q1, Q2
+
R_{SHUNT}
R6
R73, R8
Q12
E_{OUT}

MODE B 100 mA, 1A

RANGE	R_{SHUNT}	R_I	RELAYS	FET SWITCHES	FULL SCALE E_{OUT}
100 mA	R2, R1	R7, R70, R71	K1, K3	Q20, Q32, Q29, Q12	1.6V
1 A	R1	R7, R68, R69	K2, K3	Q20, Q29, Q28, Q12	2.0V

Q11 and either Q3 or Q4 will be conducting in all ranges

Figure 603-1. Current Shunt Configurations And Range Information

603-12. Mode B configures the amplifier as a difference amplifier measuring the voltage across a shunt. The ratio of the feedback resistor, R66, to R_I sets the gain of the amplifier at approximately 20 [$R66/R_I = (R8 + R73)/R6$].

603-13. The amplifier consists of a dual FET (Q19), U1, Q1, and Q2. Refer to the schematic. R18 biases Q19 from the −7V reference (from the A/D Converter). R57 and R58 are selected to compensate for offset error (one of them will always be 10Ω). R55 and R56 are selected for temperature coefficient compensation. Q1 and Q2 are a complementary pair (for either polarity output) to increase the current output capability of the amplifier.

603-14. Q11 and relay K3 are always closed for current measurements. Q3 and Q4 control the ground reference selection for the amplifier. In the dc mode, Q3 connects the noninverting input of the amplifier to reference common. In the ac mode the amplifier is referenced to the ac module ground (RT3) through Q4.

603-15. The Current Shunts module is addressed by IC0, 1, 3 high. At the first address, an ACK is returned and K5 is energized to sample the input voltage. If the voltage exceeds ± 45V, one section of U6 will have a high output, depending on the input polarity. The output from U6 is stored on C10. At the next address the voltage on C10 will prevent the return of the ACK response and will prevent control data from being latched into U2. An Error 4 will be displayed. In addition to overvoltage protection provided by U6, overcurrent protection is provided by CR9 and CR10 in the 100 μA, 1 mA, and 10 mA ranges, and by CR5 and CR6 in the 100 mA and 1 A ranges. A fuse in series with the Source HI terminal is located on the front panel for additional overcurrent protection.

603-16. At the second address, if the input voltage did not exceed ± 45V, termination of the address clocks range and reference control data into U2. Since relay common is Vcc, relay drivers must go low to energize a relay. FET switch drivers are configured to use a low from U2 to turn on the FET (close the switch) by turning off the gate control transistor.

603-17. MAINTENANCE

603-18. Performance Test

603-19. Test the direct current function by using the following procedure.

1. Select ADC and AUTO.
2. Connect the direct current source output HI to the instrument SOURCE HI and output LO to SOURCE LO.
3. Using Table 603-2, sequentially apply the inputs shown, manually selecting the range after the first reading. The instrument must read within the limits specified.

Table 603-2. Performance Test

Range	DC Input	Reading	
		Low (exp.)	High (exp.)
100 uA	10 uA	9.987 (−6)	10.013 (−6)
100 uA	100 uA	99.960 (−6)	100.040 (−6)
100 uA	250 uA	249.915 (−6)	250.085 (−6)
1 mA	0.1 mA	0.09987 (−3)	0.10013 (−3)
1 mA	1.0 mA	0.99960 (−3)	1.00040 (−3)
1 mA	2.0 mA	1.99930 (−3)	2.00070 (−3)
10 mA	1.0 mA	0.9996 (−3)	1.0004 (−3)
10 mA	10 mA	9.9960 (−3)	10.0040 (−3)
10 mA	15 mA	14.9945 (−3)	15.0055 (−3)
100 mA	10 mA	9.930 (−3)	10.070 (−3)
100 mA	100 mA	99.930 (−3)	100.070 (−3)
100 mA	150 mA	149.905 (−3)	150.095 (−3)
1A	0.1A	0.09975	0.10025
1A	1A	0.99930	1.00070

603-20. Calibration

603-21. Before calibrating any part of the instrument, the Calibration Memory module should be removed if installed. Apply power and allow a two hour warm-up period. All adjustments are on the Current Shunts module. DC calibration should be performed before calibrating current. Use the following procedure to calibrate the Current Shunts module.

1. Verify that the instrument is in the 1A range and the Cal mode (CAL indicator illuminated).
2. Connect the test DVM HI input lead to TP3 and the LO input to TP1.
3. The test DVM must read less than 200 mV.
4. Remove the test DVM.
5. Select the 100 mA range on the instrument.
6. Adjust R17 for a reading between -0.000-1 and +0.000-1 (0.000 ± 1 cal digit).
7. Set the current source controls for an output of 20.0000V dc.
8. Connect the instrument HI input to the current source HI output inserting a 200 kΩ ± 0.01% resistor in series with the instrument HI input lead. Connect the LO input terminal to the current source LO output.
9. Select the 100 μA range on the instrument and adjust R31 for a reading between +99.999 and +100.001.
10. Disconnect the instrument HI input lead from the current source, remove the inserted resistor and reconnect the HI input lead.
11. Select a current source output of +1.00000 mA.
12. Adjust R34 for a reading between +0.99999-0 and +1.00001-0.

13. Select a current source output of 10.0000 mA.

14. Adjust R37 for a reading between +9.9999-0 and +10.0001-0.

15. Select a current source output of 100.000 mA.

16. Adjust R71 for a reading between +99.999-0 and +100.001-0.

17. Select a current source output of 1.00000A.

18. Adjust R68 for a reading between +0.99999-0 and +1.00001-0.

19. Select the VDC function and Autorange on the instrument.

20. Select a 50V dc output from the current source.

21. Select the ADC function on the instrument.

22. ERROR 4 is displayed to show excessive voltage in the current function.

603-22. Troubleshooting.

603-23. Troubleshooting procedures for the Current Shunts module follow the format used for the mainframe instrument. Table 603-3 assures that the problem is in the Current Shunts module. Figure 603-2, Symptom Analysis, lists symptoms and possible failures in the order of probability. Table 603-4 contains address and data information used to set up the module.

603-24. Always remove power before removing or installing modules.

603-25. PARTS LIST

603-26. Table 603-5 is a parts breakdown for the Current Shunts module. Refer to Section 5 of this manual for ordering and use code information.

Table 603-3. Current Shunts Isolation

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Perform DC Volts test (Section 4). Is DC within tolerance?	2	Section 4
2	Perform Current test. Is Current within tolerance?		3
3	Remove all optional modules except Isolator and Current Shunts. Is Current now within tolerance?	4	5
4	Replace modules one at a time, testing Current between modules. Last one in when Current goes bad is faulty. Go to appropriate subsection of Section 6.		
5	Remove Isolator. Install Interconnect/Monitor pcb. Is Current within tolerance?	6	7
6	Bad Isolator. Go to subsection 608.		
7	Bad Current Shunts module. Go to figure 603-2.		

SYMPTOM	POSSIBLE FAILURE
Zero noisy or out of tolerance	Q21, Q20, Q29, U1, Q3, Q4, leaky output FETS
No zero reading	K3, K4, Q19, U1, Q1, Q2
Always zero	K3 or Q11 open
100μA, 1 mA, 10 mA ranges bad, others OK	K4 open, Q29, Q20, leaky protection diodes
100 mA, 1 A ranges bad, others OK	Q20, Q29, leaky protection diodes, Q12
High random — full-scale readings	Q19, U1, Q1, Q2
No display	U5, U2
No ACK — Error 9 or Error 4	Voltage limit circuit, U6 or leaky diode (CR14, CR15), U5, Q18
Only 100 μA range bad	Q30, Q31, Digital Control
Only 1 mA range bad	Q7, Q10, Digital Control
Only 10 mA range bad	Q8, Q9, Digital Control
Only 100 mA range bad	K2, Q32, Digital Control
Only 1 A range bad	K2, Q28, Digital Control

Q19 DC Readings with Zero Input

Drains (10Ω resistors) ≃ –0.6 V dc
Sources (40 KΩ resistors) ≃ 8.0 V dc
U1 pin 6 ≃ 0V dc

Differences between ADC and AAC

1. AC/DC Reference (ground)
2. Frequency response in AAC
3. RT1 outputs are applied to DC Signal Conditioner for DC and to optional AC module for AC (DC Signal Conditioner bypassed)

If Q19, R15, R16, R55, or R56 are replaced, it is necessary to return the module to the factory (attn: PARTS) for temperature compensation.

Figure 603-2. Symptom Analysis

Table 603-4. Address and Data Field

Address — IC0, 1, 3 High						
	ID0	ID1	ID2	ID3	ID4	ID5
Current LO Input (K3) and Output FET (Q11)	X	X	X	0	X	X
DC Reference (Q3)	0	X	X	0	X	X
AC Reference (Q4)	1	X	X	0	X	X
100μA Range	X	1	1	0	1	1
1 mA Range	X	1	1	0	0	1
10 mA Range	X	1	1	0	1	0
100 mA Range	X	1	0	0	1	1
1A Range	X	0	1	0	1	1
Voltage Check	0	0	0	0	0	0
Reset	1	1	1	1	1	1

Table 603-5. Current Shunts Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-03	⊗CURRENT SHUNTS PCB ASSEMBLY FIGURE 603-3 (MIS-4104T)	ORDER	BY	OPTION -03			
C1	CAP, TA, 0.47 UF +/-20%, 35V	161349	56349	196D474X0035HA1	2		
C2	CAP, TA, 0.47 UF +/-20%, 35V	161349	56349	196D474X0035HA1	REF		
C3	CAP, MICA, 47 PF +/-1%, 500V	284802	72136	DM15E470F	1		
C4	CAP, MICA, 150 PF +/-5%, 500V	148478	72136	DM15F151J	1		
C5	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	2		
C6	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	REF		
C7	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	1		
C8	CAP, MICA, 39 PF +/-5%, 500V	148544	72136	DM15E390J	2		
C9	CAP, MICA, 39 PF +/-5%, 500V	148544	72136	DM15E390J	REF		
C10	CAP, TA, 4.7 UF +/-20%, 25V	161943	56289	196D475X0025KA1	1		
C11	CAP, TA, 220 UF +/-20%, 6V	408682	56289	196D227X0006TE4	1		
C12	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	2		
C13	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C14	CAP, MICA, 390 PF +/-5%, 500V	148437	72136	DM15F391J	1		
C15	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	3		
C16	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	REF		
C17	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	REF		
CR1	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	14	4	
CR2	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR5	DIODE, SI, 1A, 600 PIV	112383	05277	1N4822	6	2	
CR6	DIODE, SI, 1A, 600 PIV	112383	05277	1N4822	REF		
CR7	DIODE, SI, 1A, 600 PIV	112383	05277	1N4822	REF		
CR8	DIODE, SI, 1A, 600 PIV	112383	05277	1N4822	REF		
CR9	DIODE, SI, 1A, 600 PIV	112383	05277	1N4822	REF		
CR10	DIODE, SI, 1A, 600 PIV	112383	05277	1N4822	REF		
CR11	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR12	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR14	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR15	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR16	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR17	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR18	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR19	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR20	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR21	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR22	DIODE, ZENER	325803	07910	TD333408	1	1	
H1	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		
K1	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	5		
	SWITCH, DRY REED	602714	15636	V1101	5		
K2	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	REF		
	SWITCH, DRY REED	602714	15636	V1101	REF		
K3	RELAY ASSY						
	COIL REED RELAY	269019	71707	U-6-P	REF		

Table 603-5. Current Shunts Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	SWITCH, DRY REED	602714	15636	V1101	REF		
K4	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	REF		
	SWITCH, DRY REED	602714	15636	V1101	REF		
K5	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	REF		
	SWITCH, DRY REED	602714	15636	V1101	REF		
MP1	CASE ASSY (INCLUDES MP2-MP9)	459008	89536	459008	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE, CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	412015	89536	412015	REF		
MP6	DECAL, CURRENT SHUNTS ASSY	413419	89536	413419	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP10	SOCKET, COMP. LEAD (NOT SHOWN)	343285	27264	02-09-2133	10		
MP11	SPACER, COMPONENT (NOT SHOWN)	296319	32559	T0806	10		
MP12	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	1		
Q1	XSTR, SI, NPN	218396	04713	2N3904	13	3	
Q2	XSTR, SI, PNP	195974	04713	2N3906	3	1	
Q3	XSTR, FET, N-CHANNEL	261578	89536	261578	13	3	
Q4	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q5	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q6	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q7	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q8	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q9	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q10	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q11	XSTR, FET, N-CHANNEL	393314	89536	393314	1	1	
Q12	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q13	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q14	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q15	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q16	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q17	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q18	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
Q19	XSTR, FET, DUAL, N-CHANNEL (SELECTED)	267963	89536	267963	1	1	
Q20	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q21	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q22	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q23	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q25	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q26	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q27	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q28	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q29	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q30	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q31	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q32	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		

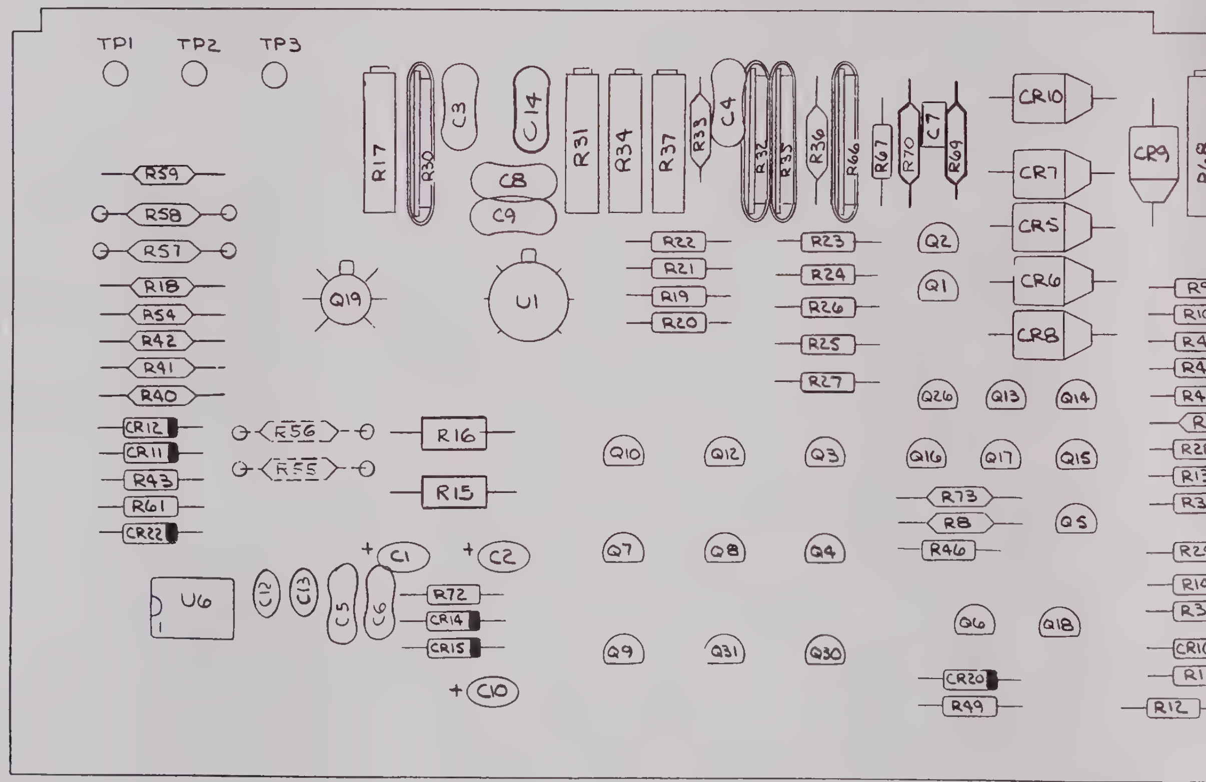
Table 603-5. Current Shunts Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q33	XSTR, SI, PNP	195974	04713	2N3906	REF		
R1	RES, WW, 0.1 +/-0.05%, 1/2W	374611	89536	374611	1		
R2	RES, WW, 0.7 +/-0.1%, 1/4W	440404	89536	440404	1		
R3	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	23		
R4	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	4		
R5	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R6	RES, MTL. FILM, 383 +/-1%, 1/8W	375899	91637	MFF1-88380F	1		
R7	RES, WW, 419 +/-0.1%, 2W	440883	89536	440883	1		
R8	RES, MTL. FILM, 7.87K +/-1%, 1/8W	294934	91637	MFF1-87871F	1		
R9	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R10	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R11	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R12	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R13	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R14	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R15	RES, WW, 40K +/-0.1%	271403	89536	271403	2		
R16	RES, WW, 40K +/-0.1%	271403	89536	271403	REF		
R17	RES, VAR, CERMET, 10 +/-20%, 1/2W	344135	75378	190PC100B	1		
R18	RES, MTL. FILM, 19.1K +/-1%, 1/8W	234963	91637	MFF1-81912F	1		
R19	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	2		
R20	RES, DEP. CAR, 18K +/-5%, 1/4W	348862	80031	CR251-4-5P18K	2		
R21	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R22	RES, DEP. CAR, 18K +/-5%, 1/4W	348862	80031	CR251-4-5P18K	REF		
R23	RES, DEP. CAR, 39 +/-5%, 1/4W	340836	80031	CR251-4-5P39E	2		
R24	RES, DEP. CAR, 39 +/-5%, 1/4W	340836	80031	CR251-4-5P39E	REF		
R25	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R26	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R27	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R28	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R29	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R30	RES, WW, 7975	440909	89536	440909	2		
R31	RES, VAR, CERMET, 50 +/-20%, 1/2W	267815	75378	190PC500B	1		
R32	RES, WW, 1020 +/-0.05%, 0.2W	440891	89536	440891	1		
R33	RES, MTL. FILM, 47.5K +/-1%, 1/8W	289546	91637	MFF1-84752F	1		
R34	RES, VAR, CERMET, 10K +/-20%, 1/2W	267880	75378	190PC103B	1		
R35	RES, WW, 128 +/-0.05%, 0.2W	440875	89536	440875	1		
R36	RES, MTL. FILM, 4.99K +/-1%, 1/8W	168252	91637	MFF1-84991	1		
R37	RES, VAR, CERMET, 1K +/-20%, 1/2W	267856	75378	190PC102B	1		
R38	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R39	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	5		
R40	RES, MTL. FILM, 49.9K +/-1%, 1/8W	268821	91637	MFF1-84992F	1		
R41	RES, MTL. FILM, 100K +/-0.5%, 1/8W	291054	91637	MFF1-81003D	2		
R42	RES, MTL. FILM, 100K +/-0.5%, 1/8W	291054	91637	MFF1-81003D	REF		
R43	RES, COMP, 10M +/-10%, 1/2W	108142	01121	EB1061	2		
R44	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R45	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R46	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R47	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R48	RES, MTL. FILM, 150K +/-1%, 1/8W	241083	91637	MFF1-81503F	1		
R49	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		

Table 603-5. Current Shunts Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R50	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R51	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R52	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R53	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R54	RES, MTL. FILM, 13K +/-1%, 1/8W	335539	91637	MFF1-81302F	1		
R55	RES, SELECTED						
R56	RES, SELECTED						
R57	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	REF		
R58	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	REF		
R59	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	REF		
R60	RES, DEP. CAR, 5.6K +/-5%, 1/4W	442350	80031	CR251-4-5P5K6	1		
R61	RES, COMP, 10M +/-10%, 1/2W	108142	01121	EB1061	REF		
R62	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R63	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R64	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R65	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R66	RES, WW, 7975	440909	89536	440909	REF		
R67	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R68	RES, VAR, CERMET, 5K +/-20%, 1/2W	267872	75378	190PC502B	2	1	
R69	RES, MTL. FILM, 12.4K +/-1%, 1/8W	261644	91637	MFF1-81242F	1		
R70	RES, MTL. FILM, 13.3K +/-1%, 1/8W	296566	91637	MFF1-81332F	1		
R71	RES, VAR, CERMET, 5K +/-20%, 1/2W	267872	75378	190PC502B	REF		
R72	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R73	RES, MTL. FILM, 100 +/-1%, 1/8W	168195	91637	MFF1-81000F	1		
R74	RES, DEP. CAR, 6.8K +/-5%, 1/4W	368761	80031	CR251-4-5P6K8	1		
U1	IC, LIN, OP AMP	483495	12040	LM318H	1	1	
U2	⊗IC, C-MOS, HEX "D" FLIP FLOP	404509	12040	MM74C174N	1	1	
U3	⊗IC, C-MOS, HEX, INVERTER/BUFFER	381848	02735	CD4049AE	1	1	
U4	IC, TTL, HEX INVERTER, BUFFER/DRIVER	327775	01295	SN7416J	1	1	
U5	⊗IC, C-MOS, TRIPLE, 3-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U6	IC, LIN, OP AMP, DUAL	418566	12040	LM358N	1	1	
U7	⊗IC, C-MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	1	1	

1 SEE TABLE 5-17 AT THE END OF SECTION 5.


TP1
TP2
TP3
R17
R30
C3
C14
C8
C9
R31
R34
R37
R33
C4
R32
R35
R36
R66
R67
R70
C7
R69
CR10
CR7
CR9
CR5
CR6
CR8
R59
R58
R57
R18
R54
R42
R41
R40
CR12
CR11
R43
R61
CR22
Q19
U1
R22
R21
R19
R20
R23
R24
R26
R25
R27
Q2
Q1
Q26
Q13
Q14
R56
R55
R16
R15
Q10
Q12
Q3
Q16
Q17
Q15
R73
R8
R46
Q5
C1
C2
Q7
Q8
Q4
U6
C12
C13
C5
C6
R72
CR14
CR15
C10
Q9
Q31
Q30
Q6
Q18
CR20
R49
R12

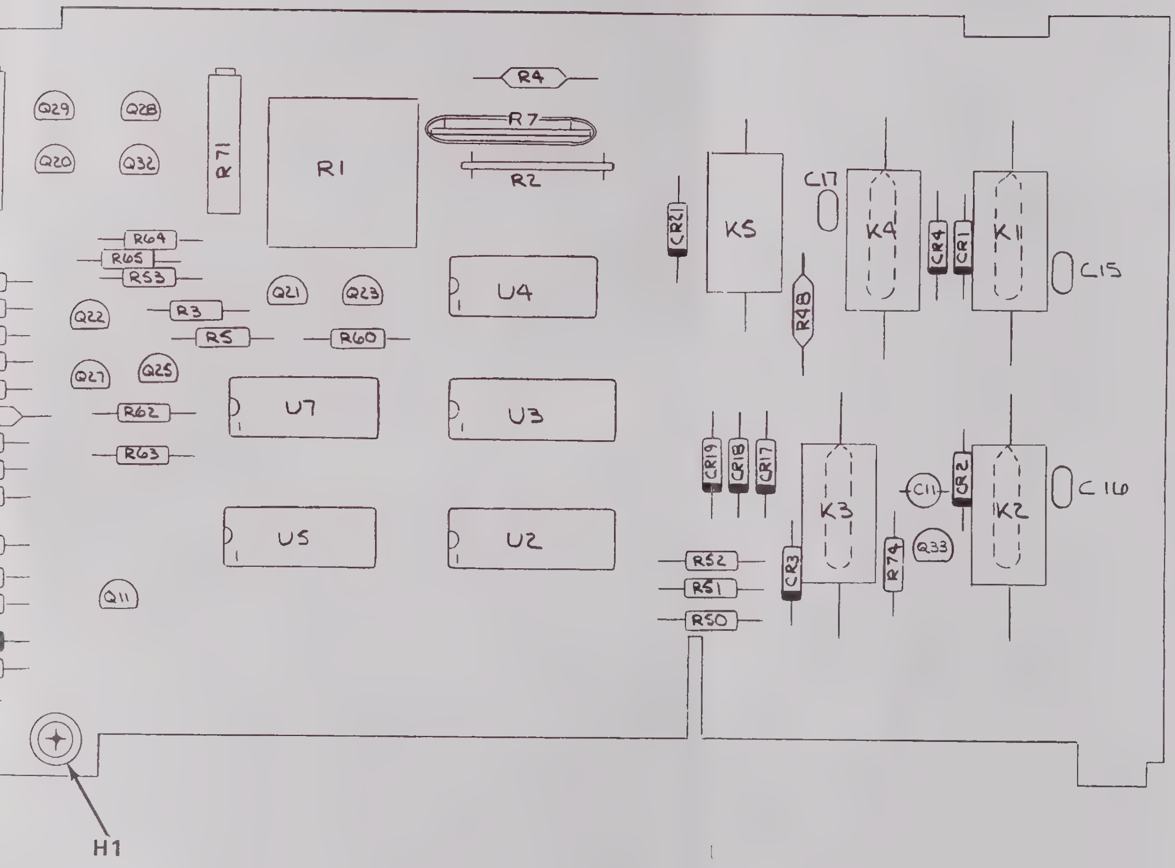
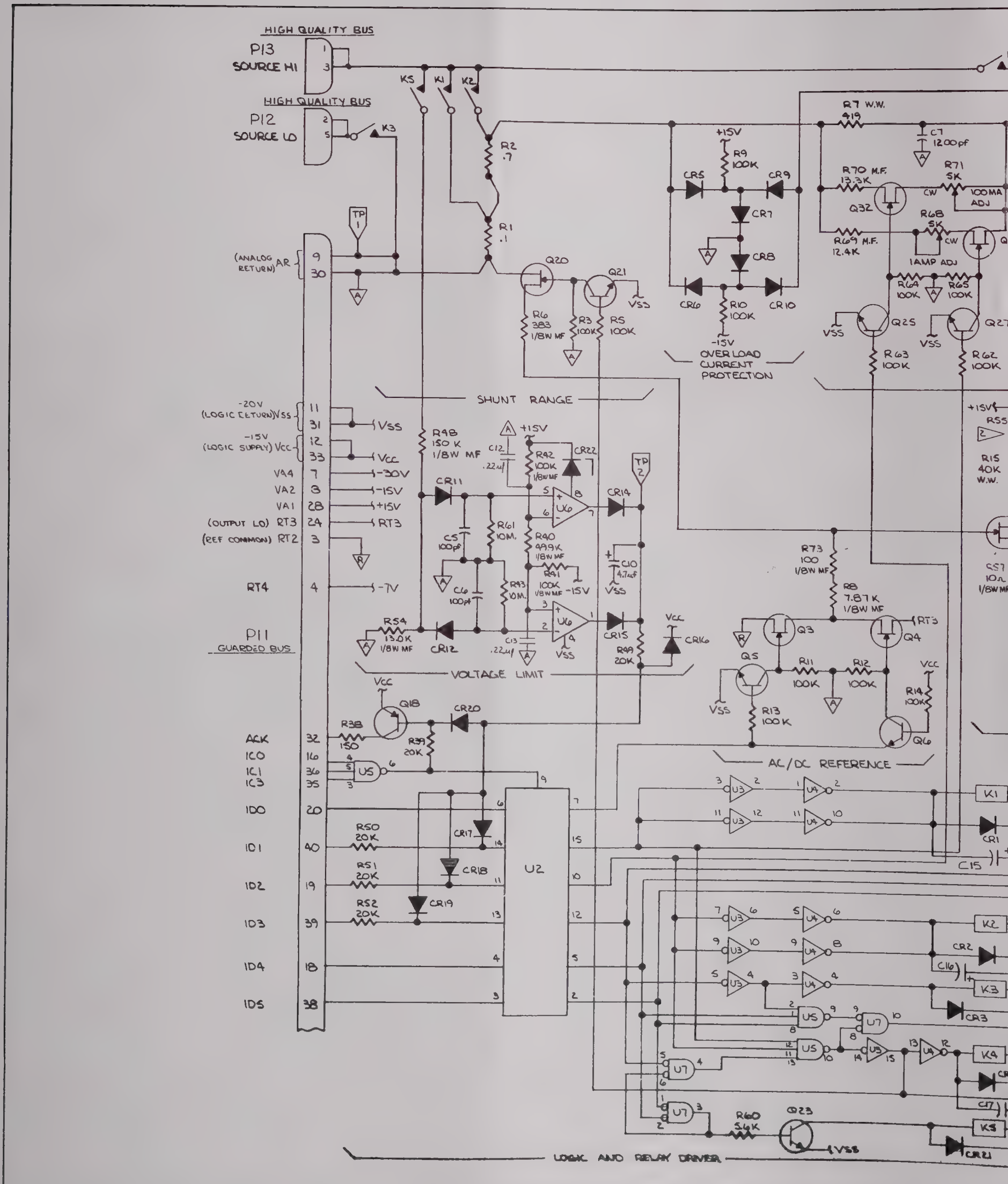
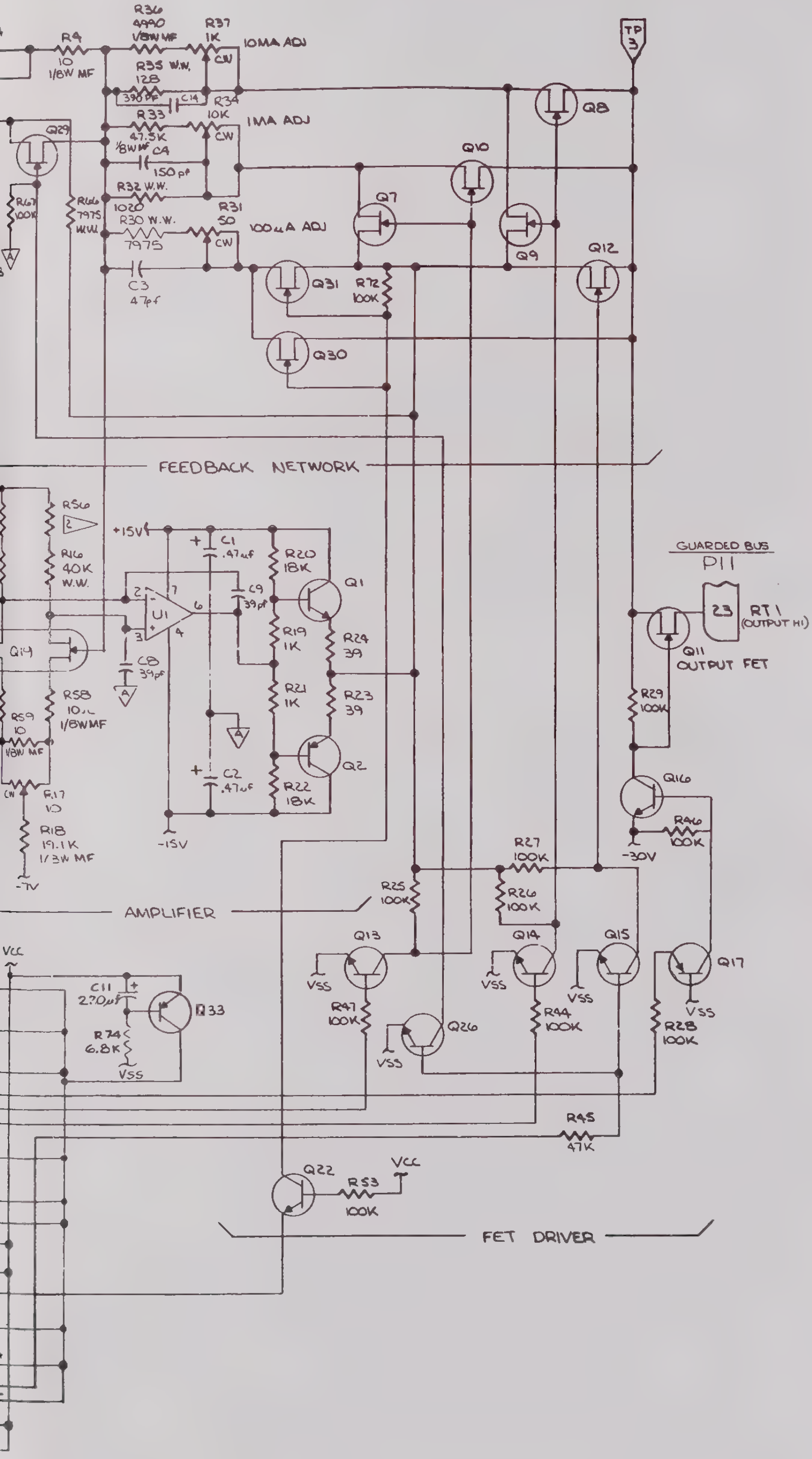

Q29
Q28
Q20
Q32
R71
R1
R4
R7
R2
CR21
K5
C17
K4
CR4
CR1
K1
C15
R64
R65
R53
Q21
Q23
U4
Q22
R3
R5
R60
R48
Q27
Q25
U7
U3
R62
R63
CR19
CR18
CR17
K3
C11
CR2
K2
C16
U5
U2
Q33
R52
R51
R50
CR3
R74
Q11
H1

Figure 603-3. Current Shunts Assembly


HIGH QUALITY BUS
P13
SOURCE HI
HIGH QUALITY BUS
P12
SOURCE LO
K5
K1
K2
K3
R2 .7
R1 .1
TP 1
(ANALOG RETURN) AR
Q20
Q21
VSS
R6 383 1/8W MF
R3 100K
R5 100K
SHUNT RANGE
+15V
R9 100K
CR5
CR9
CR7
CR8
CR6
CR10
R10 100K
-15V
OVER LOAD CURRENT PROTECTION
R7 W.W. 419
C7 1200pf
R70 M.F. 13.3K
R71 5K
CW
100MA ADJ
Q32
R68 5K
R69 M.F. 12.4K
1AMP ADJ
R64 100K
R65 100K
Q25
Q27
R63 100K
R62 100K
-20V (LOGIC RETURN) VSS
-15V (LOGIC SUPPLY) VCC
VA4
VA2
VA1
(OUTPUT LO) RT3
(REF COMMON) RT2
RT4
P11
GUARDED BUS
-30V
-15V
+15V
RT3
-7V
R48 150 K 1/8W MF
C12 .22uf
R42 100K 1/8W MF
CR22
CR11
C5 100pf
R61 10M.
U6
CR14
TP 2
R40 49.9K 1/8W MF
R41 100K 1/8W MF
C10 4.7uf
C6 100pf
R43 10M.
R54 13.0K 1/8W MF
CR12
C13 .22uf
CR15
R49 20K
CR16
VOLTAGE LIMIT
+15V
R55
R15 40K W.W.
R57 10Ω 1/8W MF
R73 100 1/8W MF
R8 7.87K 1/8W MF
Q3
Q4
Q5
R11 100K
R12 100K
R14 100K
R13 100 K
Q6
AC/DC REFERENCE
VCC
Q18
CR20
R38 150
R39 20K
ACK
IC0
IC1
IC3
U5
ID0
ID1
ID2
ID3
ID4
ID5
R50 20K
R51 20K
R52 20K
CR17
CR18
CR19
U2
U3
U4
U5
U7
K1
CR1
C15
K2
CR2
C16
K3
CR3
K4
C17
K5
CR21
R60 5.6K
Q23
LOGIC AND RELAY DRIVER


R36
4990
1/8W MF
R37
1K
10MA ADJ
CW
R4
10
1/8W MF
R35 W.W.
128
390 PF
C14
R34
10K
IMA ADJ
CW
R33
47.5K
1/8W MF
C4
150 pf
Q29
R32 W.W.
1020
R31
50
100μA ADJ
CW
R30 W.W.
7975
R67
100K
R66
7975
W.W.
C3
47pf
TP
3
Q8
Q10
Q7
Q9
Q12
Q31
R72
100K
Q30
FEEDBACK NETWORK
R56
2
R16
40K
W.W.
+15V
C1
.47uf
R20
18K
Q1
C9
39pf
U1
Q19
C8
39pf
R19
1K
R24
39
R21
1K
R23
39
R58
10
1/8W MF
R59
10
1/8W MF
R17
10
CW
R18
19.1K
1/3W MF
-7V
C2
.47uf
R22
18K
Q2
-15V
AMPLIFIER
GUARDED BUS
P11
23
RT1
(OUTPUT HI)
Q11
OUTPUT FET
R29
100K
Q16
R46
100K
-30V
R27
100K
R26
100K
R25
100K
Q13
Q14
Q15
Q17
VSS
R47
100K
R44
100K
R28
100K
Q26
VCC
C11
220uf
Q33
R74
6.8K
R45
47K
Q22
R53
100K
FET DRIVER

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS AND ALL RESISTORS 1/4W C.C..

2. SELECT AT TEST

3. LAST REF. DES. NO.'S USED R74, C11, CR22, Q33, U7, K5

4. REF. DES. NO.'S NOT USED Q24, CR13, R49

8. *IF Q19, R15, R16, R55 OR R56 ARE REPLACED, IT BECOMES NECESSARY TO T.C. THE MODULE PER MIS-4104-151 TES PROCEDURE.*

I.C. NO.	TYPE	VSS	VCC
U1	LM318	—	—
U2	74C174	8	16, 1
U3	4049	8	1
U4	7416	7	14
U5	4023	7	14
U6	LM358	—	—
U7	4001	7	14,13,12

MIS 1104

Figure 603-3. Current Shunts Assembly (cont)

Option —04
Calibration Memory

604-1. INTRODUCTION

604-2. Installation of the Calibration Memory module permits extended calibration intervals while maintaining the accuracy of the instrument. A calibration factor is entered into memory with a single keystroke. Calibration factors are determined by comparison to a standard at the cardinal point for each function and range. An input of +1.000000V dc would be the cardinal point for the 1V dc range. A non-volatile memory allows storage of calibration factors for at least one year or until the instrument is completely recalibrated.

604-3. SPECIFICATIONS

604-4. DC Zero, Ohms Zero, and calibration factors for the cardinal points of every range and function will be maintained for at least one year with no power applied to the instrument.

604-5. INSTALLATION

604-6. Refer to Section 4 of this manual under Module Installation and Removal for installation procedures. The interconnect diagram in Section 8 contains a table listing permissible and preferred slots.

604-7. OPERATING NOTES

NOTE

If this option is being used in the 8502A, high resolution may be selected independently.

604-8. When the Calibration Memory module is installed, care must be exercised when using the instrument in the high resolution mode. Inadvertently depressing the STORE switch while in the high resolution mode will erase the cal factor for that function and range from memory and enter an erroneous factor. Use the following procedure to enter calibration factors.

1. Ensure that the DC Zero and Ohms Zero procedures have been performed.
2. Verify that the EXT REF and OFFSET indicators are extinguished.
3. Select the Cal mode (CAL indicator illuminated).
4. Select the desired function and range.
5. Apply an input from a calibration source equal to the value of the cardinal point at the function and range selected (e.g., with 10V dc selected apply +10.000000V dc).
6. Depress the STORE switch. The reading displayed should be equal to the value of the input ± the listed specification as long as the switch is held in.
7. Repeat steps 4, 5 and 6 for each applicable function and range.
8. Depress the RECALL switch to display the last uncorrected reading taken while in the Cal Memory mode. The reading is displayed until the switch is released.
9. To remove Calibration factors from the Cal Memory, use the foregoing procedure, except in step 5 use a short (an open for current factors) at the input terminals instead of the calibration source.

NOTE

Correction factors entered for the V ac rms feature automatically correct any reading in dc coupled ac.

604-9. THEORY OF OPERATION

604-10. The Calibration Memory module provides non-volatile read/write memory used to store calibration constants and dc and ohms zero factors. When the dc or ohms functions are selected, the appropriate zero factor (if one was entered) is brought out by the instrument controller for storage within the controller module. Likewise, when a new function or range is selected, calibration constants are read from and stored for immediate use within the controller module.

604-11. This module was designed for use in more than one instrument, so there are land patterns and some devices which are not used in this particular instrument on the pcb. The following discussion is keyed to the schematic, Figure 604-1.

604-12. RAM Location Addresses

604-13. RAM location addresses are sent to the Calibration Memory module on the instrument data bus, ID0-7. Address IC1, 2, 6 clocks the data into U23 through U15-10, and U14-12. Outputs from U23 determine the location in the RAMs that data will be written or read.

604-14. Write Operation

604-15. Addresses used in both read and write operations are true 3 of 7 codes in which three IC lines must be high and four low to obtain a response. Writing data into memory first requires an address (IC3, 4, 5 high) and a data key (ID 0, 3, 5, 6 high, ID 1, 2, 4, 7 low) to set the circuitry into the write mode. The address is decoded by U15-9, U14-1 ANDed by U13-3 (VA1). The data key is decoded by U24-13, U24-1 ANDed by U13-4 (KEY). VA1 and KEY are ANDed by U2-11 to produce the ACK response (U17, Q1) and to set U12-2 low (WRITE) through U25-10. The module is now set into the write mode.

604-16. The next address (IC0, 2, 6 high) is decoded by U15-6, U14-13 ANDed by U13-10 (VA2). VA2 triggers a one-shot multivibrator, U1-4, so U2-5, 6 are both low and VA2·WRITE is true (low) which sets the RAMs into the write mode. U12-1 is high so U2-3 is high which disables the outputs of the RAMs (OD). Data to be written into the RAMs accompanies this address and is stored in the memory location previously clocked into U23. At termination of the address, VA2 goes high clocking U12-1 low and U12-2 high, which sets the module into the read mode.

604-17. Read Operations

604-18. The module stays in the read mode unless set into the write mode. Read operations require the address resulting in VA2 as previously explained. This time U12-1 is low (READ). U2-3 goes low enabling the RAM outputs. U2-4 is high setting the RAMs (R/W) into the read mode. The desired memory location must have been clocked into U23 prior to the READ address.

604-19. TROUBLESHOOTING

604-20. Problems in the Calibration Memory can cause apparent problems in all functions of the instrument. The most common problem is wrong values entered. The recall feature may be used to determine the value of the stored correction factor. Since correction factors are multipliers, the stored value will be close to one and consequently difficult to display meaningfully. Instead, the last uncorrected reading is displayed when in the CAL mode, and the RECALL switch is depressed. Dividing the cardinal value for the selected range into the last uncorrected reading results in the stored constant. By using the recall feature, it is fairly easy to determine if a reasonable cal constant is stored.

604-21. The three following checks may be made to determine if the Calibration Memory is functioning properly.

1. Store zeros for all functions and ranges, then recall the zero values.
2. Store cardinal points for all functions and ranges, then recall for the last uncorrected reading.
3. Remove power for two or more hours (to ensure that the RAMs have discharged C7 to the battery level), then reapply power and recall as in 1 and 2. This checks the shift of RAM power supply from Vcc to battery and back to Vcc. The purpose of C7 is to remove glitches in the RAM supply which can scramble entries stored in RAM.

604-22. Table 604-1 lists the test points found on the Calibration Memory module. Table 604-2 gives a symptom analysis approach to troubleshooting.

604-23. PARTS LIST

604-24. Table 604-3 gives a parts breakdown for the Calibration Memory module. Refer to Section 5 of this manual for ordering and use code information.

Table 604-1. Test Points

TP1 — Vss; logic return, use as LO return for test instrument
TP2 — VA2 · READ; low for the controller to read from cal memory goes low 3 or 4 times every 200 msec
TP3 — VA2 · WRITE; low for the controller to write into cal memory goes low 4 times for every STORE switch push
TP4 — RAM Supply Voltage; when power is on =Vcc — .6V
when power is off = battery voltage
TP5 — Negative Battery Terminal
TP6 — Vcc; Logic Supply
TP7 — ACK; acknowledge signal returned when module addressed

Table 604-2. Symptom Analysis

SYMPTOM	POSSIBLE FAILURE
Won't Store	VA2 · WRITE missing; check TP3
Won't Read	VA2 · READ missing; check TP2
Error at Turn-On	Battery voltage bad at TP4, RAM defective, not reading
Wrong Readings	U23 (RAM address latch), RAM defective, wrong data stored

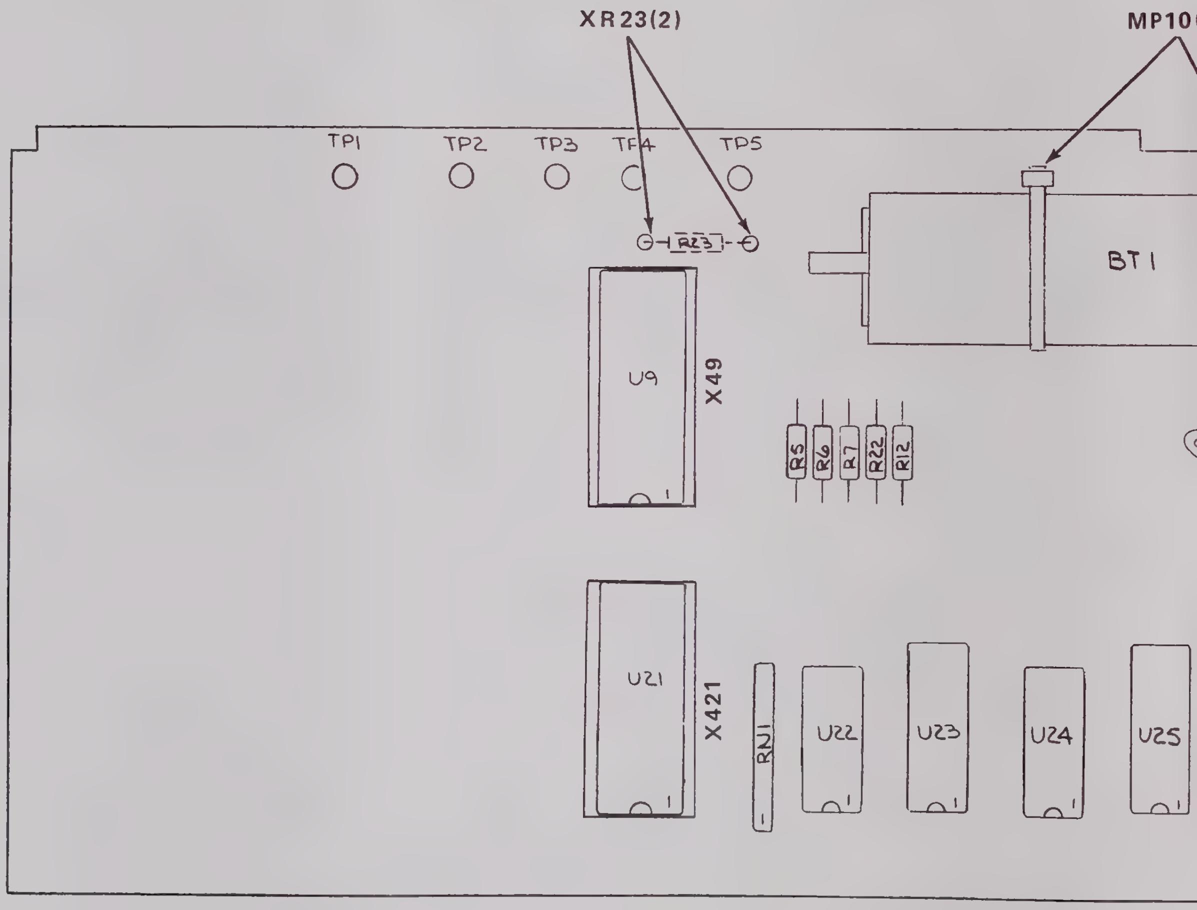
Table 604-3. Calibration Memory PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-04	⊗CALIBRATION MEMORY PCB ASSEMBLY FIGURE 604-1 (8500A-4160T)	ORDER	BY	OPTION -04			
BT1	BATTERY, LITHIUM (USE WHEN R20 & CR4 ARE NOT INSTALLED)	448498	89536	448498	1		
BT1..	(CAUTION-DO NOT RECHARGE)						
BT1...	BATTERY, NI-CAD	412890	06001	PPS2092	1		
BT1..1	(USE WHEN R20, CR4, U9 & U21						
BT1..2	ARE INSTALLED)						
C2	CAP, TA, 0.47 UF +/-20%, 35V	161349	56289	196D474X0035HA1	1		
C3	CAP, MICA, 180 PF +/-5%, 500V	284786	72136	DM15F181J	1		
C5	CAP, TA, 1 UF +/-20%, 35V	161919	56289	196D105X0035JA1	1		
C7	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	1		
CR1	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	2	1	
CR4	DIODE, HI-SPEED SWITCHING (USE WITH NI-CAD BATTERIES INSTALLED)	203323	07910	1N4448	REF		
H1	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		
MP1	MODULE CASE ASSY (INCLUDES MP2-MP9)	458919	89536	458919	1		1
MP2	CASE, HALF, MODULE	402990	89536	402990	REF		
MP3	CASE, HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411975	89536	411975	REF		
MP6	DECAL, CALIBRATION MEMORY	413484	89536	413484	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP10	TIE, CABLE, NYLON (USED ON BT1)	172080	06383	SST-1M	2		
MP11	SOCKET, COMP, LEAD	343285	00779	2-331272-6	2		
MP12	SPRING, COIL	424465	83553	C0120=014-0380	1		
Q1	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
Q3	XSTR, SI, NPN	168716	89536	168716	1	1	
Q4	XSTR, FET, N-CHANNEL	370072	89536	370072	1	1	
Q5	XSTR, SI, PNP	195974	04713	2N3906	1	1	
R1	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R2	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R4	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	10		
R5	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R6	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R7	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R8	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R9	RES, MTL. FILM, 10K +/-1%, 1/8W	168260	91637	MFF1-81002F	1		
R12	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R13	RES, MTL. FILM, 34K +/-1%, 1/8W	261602	91637	MFF1-83402F	1		
R14	RES, MTL. FILM, 6.04K +/-1%, 1/8W	285189	91637	MFF1-86041F	1		
R15	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R20	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	1		
R20.	(USE WITH NI-CAD BATTERIES INSTALLED)						
R21	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R22	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R23	RES, DEP. CAR, 10K +/-5%, 1/4W (USED WITH LITHIUM BATTERY)	348839	80031	CR251-4-5P10K	1		

Table 604-3. Calibration Memory PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R25	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R26	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	1		
RN1	RES, NETWORK	412908	89536	412908	2	1	
RN2	RES, NETWORK	412908	89536	412908	REF		
U1	IC, TTL, LO-POWER SCHOTTKY	404186	01295	SN74L123N	1	1	
U2	⊗IC, C-MOS, QUAD, 2-INPUT OR GATES	408393	18725	CD4071BE	1	1	
U3	⊗IC, C-MOS, DUAL PAIR PLUS INVERTER	408013	02735	CD4007AE	2	1	
U4	⊗IC, C-MOS, DUAL PAIR PLUS INVERTER	408013	02735	CD4007AE	REF		
U9	⊗IC, C-MOS, 1024 BIT STATIC RAM (USED WITH LITHIUM BATTERIES INSTALLED)	429860	34649	P5101L	2	1	
	⊗IC, C-MOS, 1024 BIT STATIC RAM (USED WITH NI-CAD BATTERIES INSTALLED)	408757	34649	P5101L-3	2	1	
U12	⊗IC, C-MOS, DUAL D-TYPE FLIP FLOP	340117	02735	CD4013AE	2	1	
U13	⊗IC, C-MOS, QUAD, 2-INPUT NAND GATES	355198	02735	CD4011AE	1	1	
U14	⊗IC, C-MOS, DUAL, 4-INPUT NOR GATES	363820	02735	CD4002AE	1	1	
U15	⊗IC, C-MOS, TRIPLE, 3-INPUT AND GATES	408807	02735	CD4073B	1	1	
U17	⊗IC, C-MOS, DUAL 4-INPUT AND GATES	408799	02735	CD4082B	2	1	
U21	⊗IC, C-MOS, 1024 BIT STATIC RAM	429860	34649	P5101L	REF		
	(USED WITH LITHIUM BATTERIES INSTALLED)				REF		
	⊗IC, C-MOS, 1024 BIT STATIC RAM	408757	34649	P5101L-3	REF		
	(USE WITH NI-CAD BATTERIES INSTALLED)				REF		
U22	⊗IC, C-MOS, DUAL D-TYPE FLIP FLOP	340117	02735	CD4013AE	REF		
U23	⊗IC, C-MOS, HEX D-TYPE FLIP FLOP	404509	12040	MM74C174N	1	1	
U24	⊗IC, C-MOS, DUAL 4-INPUT AND GATES	408799	02735	CD4082B	REF		
U25	⊗IC, C-MOS, HEX, INVERTER/BUFFER	381848	02735	CD4049AE	1	1	
XR23	SOCKET, COMP, LEAD	343285	00779	2-331272-6	2		
XU9	SOCKET, IC, 22 PIN	453126	91506	322-AG39D	2		
XU21	SOCKET, IC, 22 PIN	453126	91506	322-AG39D	REF		

1 SEE TABLE 5-17 AT THE END OF SECTION 5.


XR23(2)
MP10
TP1
TP2
TP3
TP4
TP5
R23
BT1
U9
X49
R5
R6
R7
R22
R12
U21
X421
RN1
U22
U23
U24
U25
1

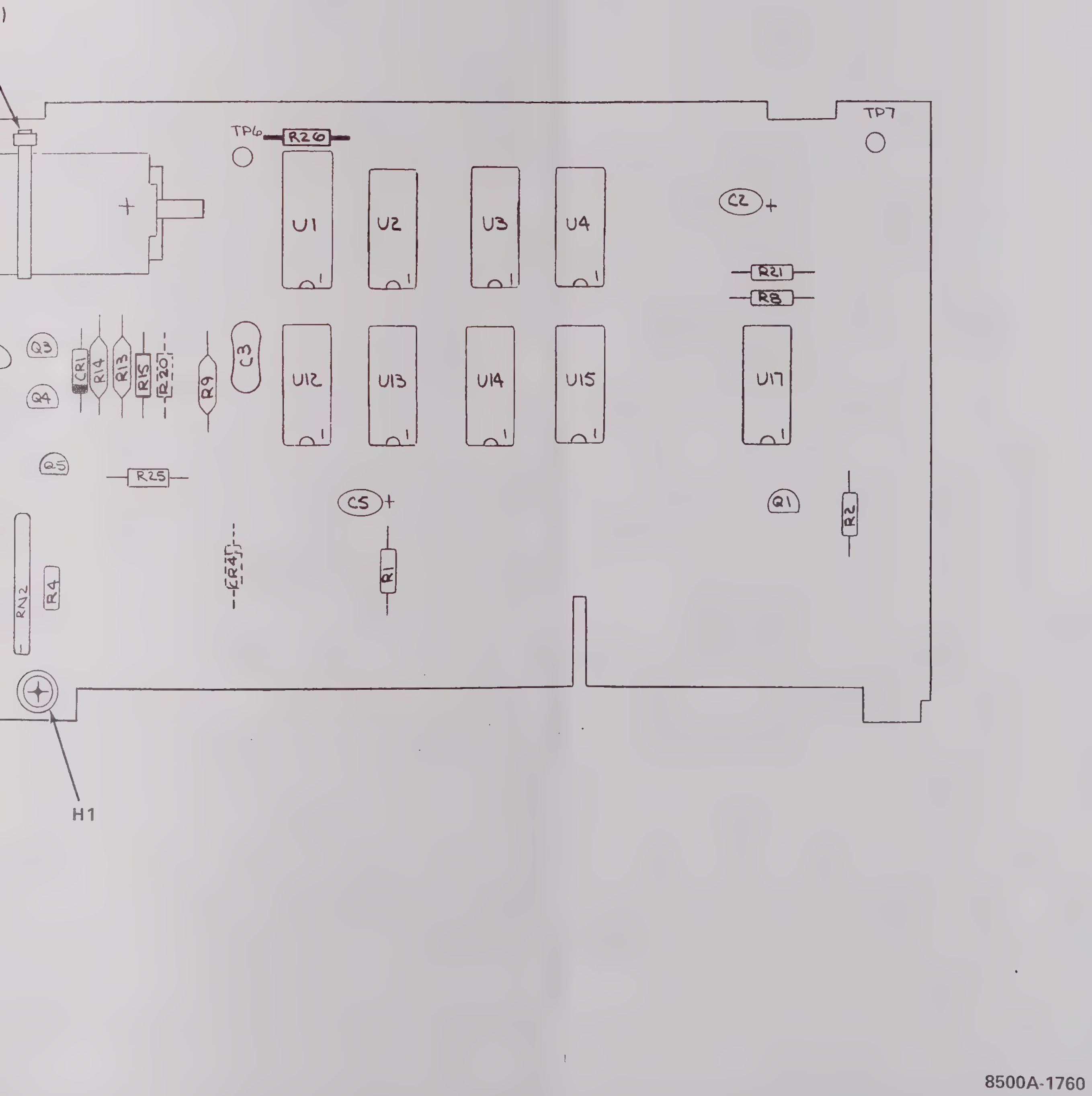
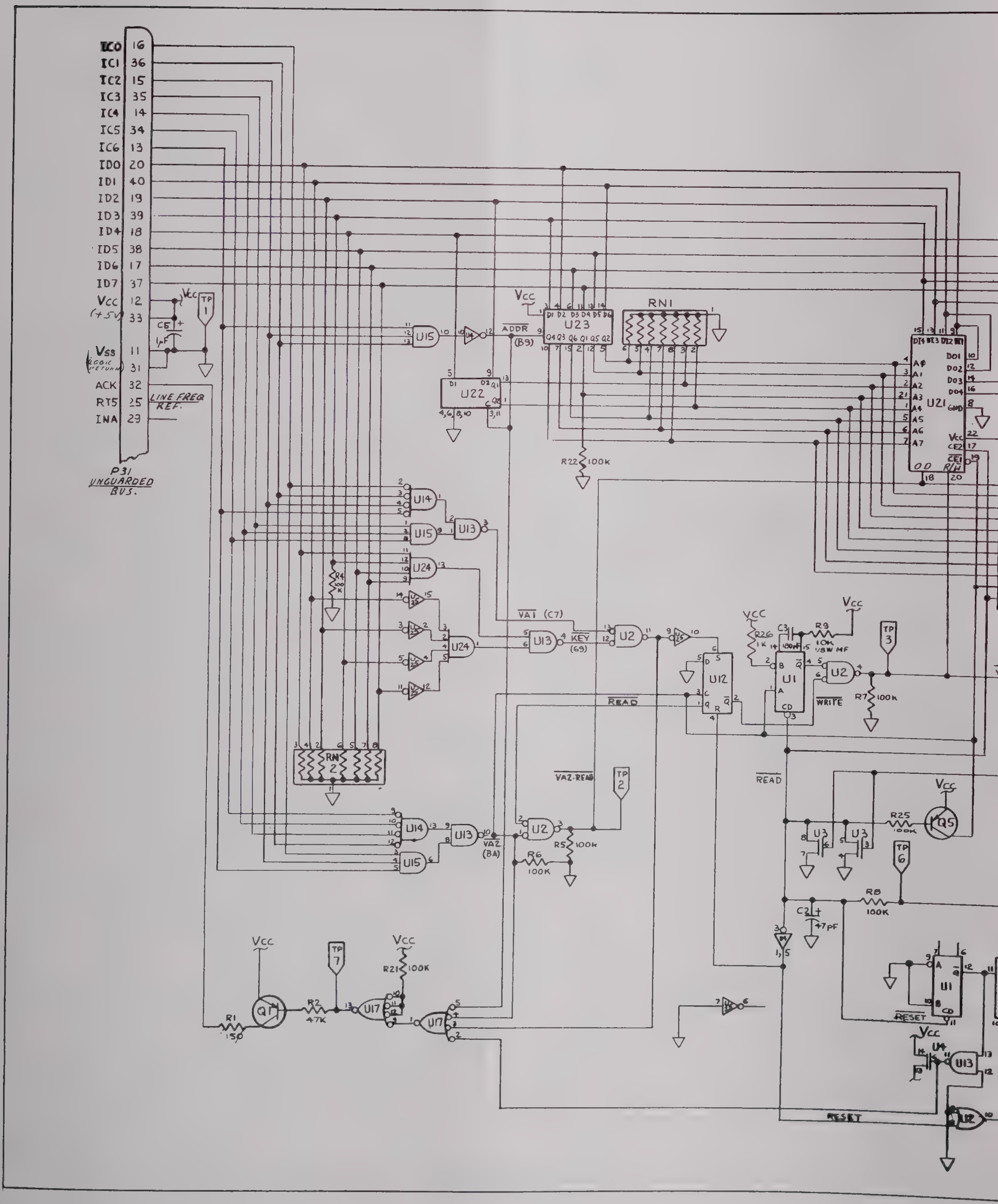
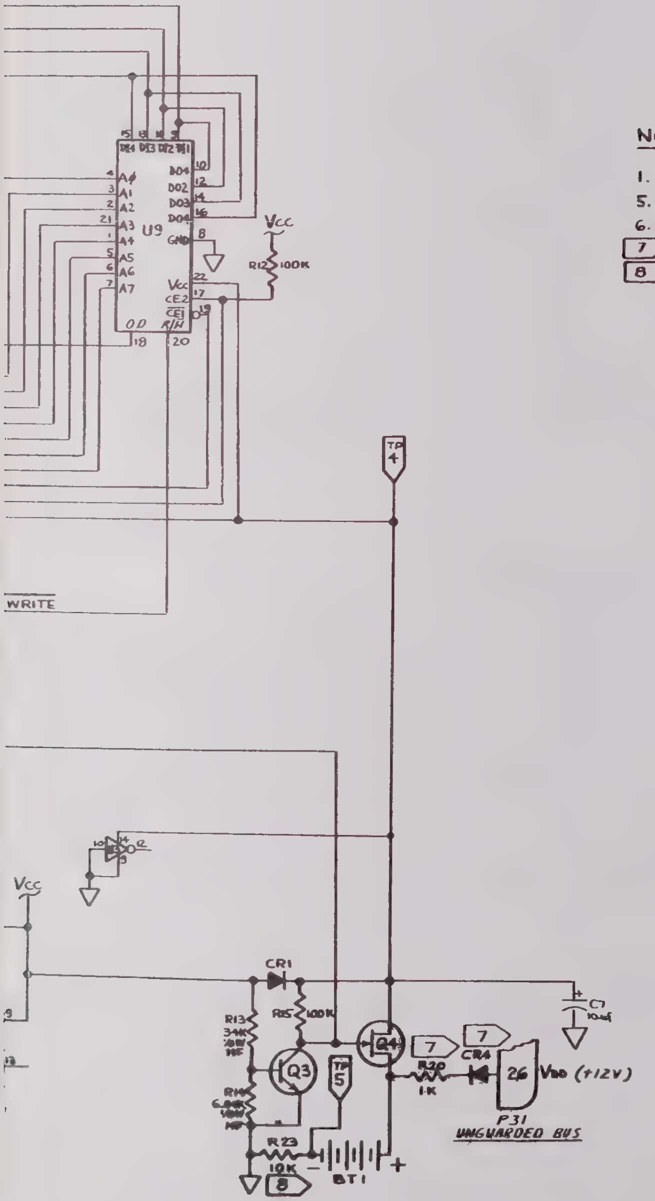

TP6
R26
TP7
C2
U1
U2
U3
U4
R21
R8
Q3
Q4
CR1
R14
R13
R15
R20
R9
C3
U12
U13
U14
U15
U17
Q5
R25
C5
Q1
R2
RN2
R4
CR4
R1
H1
8500A-1760

Figure 604-1. Calibration Memory PCB Assembly



IC0 16
IC1 36
IC2 15
IC3 35
IC4 14
IC5 34
IC6 13
ID0 20
ID1 40
ID2 19
ID3 39
ID4 18
ID5 38
ID6 17
ID7 37
Vcc (+5V) 12 33
Vss (LOGIC RETURN) 11 31
ACK 32
RTS 25
INA 23
LINE FREQ REF.
P31 UNGUARDED BUS.
C5 1µF
TP 1
Vcc
U15
U4
ADDR (B9)
U23
RN1
U22
R22 100K
U21
A0 A1 A2 A3 A4 A5 A6 A7
DO1 DO2 DO3 DO4
GND
Vcc
CE2
CE1
OD
R/W
U14
U13
U24
R4 100K
U25
VA1 (C7)
KEY (69)
U2
U12
READ
R26 1K
C3 100PF
R9 10K 1/8W MF
U1
WRITE
TP 3
R7 100K
RN 2
VA2-READ
TP 2
VA2 (BA)
R5 100K
R6 100K
READ
U3
R25 100K
Q5
TP 6
R8 100K
C2 47PF
Vcc
Q1
R1 150
R2 47K
TP 7
R21 100K
U17
RESET
RESET
U13
U12


U9
A∅
A1
A2
A3
A4
A5
A6
A7
DI4
DI3
DI2
DI1
DO1
DO2
DO3
DO4
GND
Vcc
CE2
CE1
OD
R/W
4
3
2
21
1
5
6
7
15
13
11
9
10
12
14
16
8
22
17
19
18
20
Vcc
R12 100K
TP 4
WRITE
10
14
12
9
Vcc
CR1
R15 100K
R13 34K 1/8W 1%F
R14 6.98K 1/8W 1%F
Q3
TP 5
Q4
7
7
R20 1K
CR4
26
VDD (+12V)
C7 10µf
P31
UNGUARDED BUS
R23 10K
8
BT1
−
+

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTOR 1/4W, CC, ALL RESISTANCE IN OHMS.

5. LAST REF. DES. NO'S USED: U25, Q5, CR4, C7, RN2, R23, BT1.

6. REF. DES. NO.'S NOT USED: U5-U8, U10, U11, U16, U18-U20, R3, R17-R19, CR3, C1, R10, R11, R16, R24, CR2, C4 AND C6

7 CR4 & R20 ARE ONLY USED WHEN NICKEL CADMIUM BATTERY (BT1) IS INSTALLED.

8 R23 WILL BE INSTALLED WHEN USING LITHIUM BATTERY.
A JUMPER WILL BE INSTALLED WHEN USING NI-CAD BATTERY.
CAUTION — THIS ITEM SHOULD BE INSTALLED DURING TEST, TO AVOID CURRENT DRAIN FROM BATTERY, WHICH COULD OCCUR DUE TO INSTALLATION OF FAULTY COMPONENTS.

8500A-1160

Figure 604-1. Calibration Memory PCB Assembly (cont)

Option -05
IEEE-488 Interface

605-1. INTRODUCTION

605-2. This manual will specifically describe the IEEE Interface (Option -05); refer to the IEEE standard for general IEEE-488 bus interface information. Descriptions unique to the IEEE Interface will be presented separately from Programming Instructions in this manual. The Systems Multimeter Programming Card provided with the DMM lists condensed programming instructions. Refer also to Fluke Application Bulletins 25 and 36, and the IEEE Standard 488-1975 Digital Interface for Programmable Instrumentation.

605-3. SPECIFICATIONS

605-4. Specifications for the IEEE 488-1975 Standard Interface, Option -05, conform to those established in the IEEE Standard Digital Interface for Programmable Instrumentation as published by the Institute of Electrical and Electronics Engineers; 345 E. 47th Street, New York, N.Y. 10017. For an explanation of the IEEE 488-1975 Standard, refer to the Standard Document.

605-5. INSTALLATION

605-6. The IEEE-488 Interface is easily installed as a module in the 8500 Series DMM. Use the following installation procedure:

1. On the DMM, press power OFF and remove the line power cord.

2. Remove the DMM's top cover.

3. The Interface module fits in the rear slot, bus connector and addresss switches facing to the rear. Slide the module vertically between the module guides, and press firmly into place.

NOTE

Make sure the leaf spring, attached to one-half of the module shield, is resting firmly over the flange of the opposite half of the module shield.

4. If installed, remove the Interconnect PCB from slot K. This slot can be identified as the only slot with connectors on the analog and digital bus lines. To remove the Interconnect PCB, grasp the board at both ends and pull up. An end-to-end rocking motion may be necessary to free the PCB from its connectors.

5. The Isolator module must be installed in slot K whenever a remote interface (Option -05, -06 or -07) is used in the DMM.

NOTE

Use Isolator -08 with the 8500A; Isolator -08A must be used with the 8502A.

6. Connect the Interface to the IEEE-488 Bus. Attach a standard 24-pin cable to the bus connector accessed through the DMM's rear panel. Standard cables, listed in Table 605-1, are available from John Fluke Mfg. Co., Inc.

7. Optionally, connect the cable shield to chassis ground. The shield, pin 12 in the connector, is accessed from the rear panel via a banana jack. Chassis ground is available at a binding post on the DMM's rear panel.

8. Set the Interface address switches (A1-A5) as required. Controls and connections accessed through the rear panel are illustrated in Figure 605-1. Refer to Table 605-2 for permissable address settings. Depressing a switch to the bottom sets the associated address bit true (true = 1). TALK address bits T1 through T5 are equal to LISTEN address bits L1 through L5.

NOTE

If the other devices in the system are listeners only, the DMM may be place in TALK ONLY mode by toggling the TALK/ ADDRESSABLE switch; access to this switch is through the rear panel.

9. Replace the DMM's top cover.

10. Energize the DMM.

11. Remote operation can be entered by transmitting any character that the DMM will recognize from the remote controlling terminal. When remote operation is entered, use of DMM front panel switches (other than RESET or POWER) will be ignored.

Table 605-1. IEEE-488 Standard Cables

ORDER NUMBER	DESCRIPTION
Y8001	IEEE-488 Cable, 1 meter
Y8002	IEEE-488 Cable, 2 meters
Y8003	IEEE-488 Cable, 4 meters

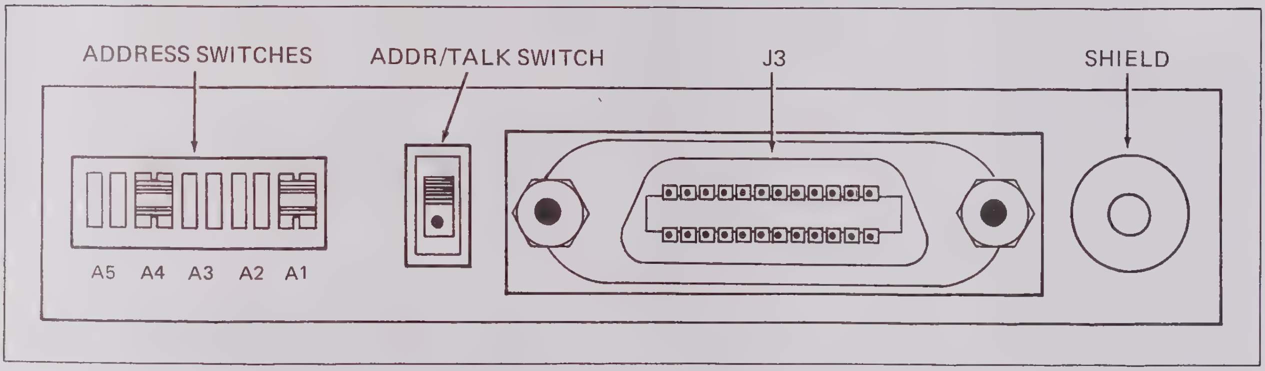


Figure 605-1. Rear Panel Access

Table 605-2. Allowable Listen and Talk Addresses

DECIMAL	5 4 3 2 1 BINARY	ASCII CHARACTER LISTEN	ASCII CHARACTER TALK	DECIMAL	5 4 3 2 1 BINARY	ASCII CHARACTER LISTEN	ASCII CHARACTER TALK
0	0 0 0 0 0	SP	@	16	1 0 0 0 0	0	P
1	0 0 0 0 1	!	A	17	1 0 0 0 1	1	Q
2	0 0 0 1 0	"	B	18	1 0 0 1 0	2	R
3	0 0 0 1 1	#	C	19	1 0 0 1 1	3	S
4	0 0 1 0 0	$	D	20	1 0 1 0 0	4	T
5	0 0 1 0 1	%	E	21	1 0 1 0 1	5	U
6	0 0 1 1 0	&	F	22	1 0 1 1 0	6	V
7	0 0 1 1 1	'	G	23	1 0 1 1 1	7	W
8	0 1 0 0 0	(	H	24	1 1 0 0 0	8	X
9	0 1 0 0 1	)	I	25	1 1 0 0 1	9	Y
10	0 1 0 1 0	*	J	26	1 1 0 1 0	:	Z
11	0 1 0 1 1	+	K	27	1 1 0 1 1	;	[
12	0 1 1 0 0	,	L	28	1 1 1 0 0	<	\
13	0 1 1 0 1	–	M	29	1 1 1 0 1	=	]
14	0 1 1 1 0	.	N	30	1 1 1 1 0	>	^
15	0 1 1 1 1	/	O				

605-7. OPERATING FEATURES

605-8. Attached to the assembly and accessible through a port on the rear panel (Figure 605-1) are a standard specified connector, five address switches and a Talk Only Mode switch. The connector is standard for the IEEE bus and is specified by the standard document. The address of the instrument is set using the five address switches. The characters used to address the instrument in the talk and listen mode are given in Table 605-1. The five low order bits of the message determine the address, the next two higher bits differentiate between the Talk and Listen modes. Normal operation allows the instrument to both talk and listen to the bus. The Listen mode can be disabled with the Talk Only switch, if desired.

605-9. OPERATING NOTES

605-10. Interface Control

605-11. Information is input to the interface from the controller on the system bus, which contains eight data lines, three handshake lines and five bus management lines. Control of the handshake and management lines is from the controller and will vary with the controller used. Refer to the instructions with the system controller for the information on how to obtain the correct level on these lines. The lines and a brief explanation of their function are given in Table 605-3. Refer to the IEEE 488-1975 Standard Manual for a further explanation of their function.

605-12. Interface Messages

605-13. Multiple line messages are input to the interface from the controller using the data lines. The messages used within the instrument are listed with their codes in Table 605-4. Further information on the messages can be obtained from the IEEE 488-1975 Standard Manual.

605-14. Status Request Responses

605-15. If enabled by the applicable Interface Interrupt Enable Code, a service request (SRQ) can be generated within the interface by either an error or ready condition. When the instrument is addressed during a serial poll operation by the IEEE 488 Controller, and an interrupt is generated, the response byte will be a zero for ready or the numeric of the applicable Error Code. If the SRQ was not generated, the response is a null character (binary 000000000) to the controller.

605-16. THEORY OF OPERATION

605-17. The IEEE Interface provides for communication between the IEEE system bus and the DMM internal bus structure. The IEEE system bus is defined by the IEEE standard; the DMM internal bus structure is discussed in the instrument Instruction Manual. System bus signal lines will be referred to by their mnemonic designators (refer to Table 605-3 for definitions).

605-18. The IEEE Interface consists of two interconnected pcb's in one module. Each pcb will have its own reference designator system. To distinguish between the two, reference designators mounted on the Piggyback board will be followed by a (PB).

605-19. Data Lines

605-20. System bus data lines (DI01-08) are applied to the interface through receiver/drivers, U21 and U24. The receivers consist of noninverting buffers, while the drivers are gates with a common enable line from U32-8.

> *NOTE*
>
> *True conditions on the system data bus are defined as a low; true conditions on the instrument bus are defined as a high.*

Outputs from the data line receiver drivers are applied directly to address decoders, U19 and U12, through address switch S1 to address decoders U6 and U3, and through inverters to a data register consisting of U30 and part of U31.

605-21. The internal DMM data bus is applied to a response register consisting of U26 and U29. This register latches data up for application to the system bus lines (the system bus requires that data be held longer than is desirable to tie up the instrument controller). Instrument data is also applied to the control register on the Piggyback board (U11-PB, U16-PB, U14-PB).

605-22. Addresses

605-23. Instrument address lines (IC0-IC6) are applied to address decoders located on the Piggyback board. All of the following listed addresses cause an ACK to be returned to the instrument controller through U6 (PB)-1.

1. IC 1, 5 and 4 High: Decoded U12 (PB)-6 to enable the response register.
2. IC 6, 4 and 3 High: U12(PB)-10 to clock data into the control register; if ID0 is high, this address also causes a Return to Local signal from U8(PB)-3.
3. IC 5, 3 and 0 High: Decoded by U13(PB)-6 to cause a software reset through U8(PB)-10.
4. IC 6, 0 and 4 High: Decoded by U13(PB)-9 to enable the status register (U28 and part of U31).
5. IC, 6, 1 and 4 High: Decoded by U13(PB)-10 to enable the data register (U30 and part of U31).

605-24. Addresses to the IEEE Interface from the system are received on the data lines when ATN is true. Address switch S1 routes My Listen Address (MLA) and My Talk Address (MTA). Decoding for MLA is done by U6-13; the DAV signal clocks this address into U11-1. The MTA flip-flop U11-1 is cleared by the UNL (Unlisten) signal (decoded by U19-13). The Message Decoder (U9, U5 and U8) is enabled by the ATN and U12-10 (decoded by DI02, DI06, DI07).

Table 605-3. Mnemonics

PIN	MNEMONICS	FUNCTION	COMMENTS
1	DIO 1	Data	Data input/output lines. Message bytes are carried on the DIO lines in a bit-parallel byte-serial form, asynchronously, and generally in a bidirectional manner.
2	DIO 2	Data	
3	DIO 3	Data	
4	DIO 4	Data	
13	DIO 5	Data	
14	DIO 6	Data	
15	DIO 7	Data	
16	DIO 8	Data	
5	EOI	End Or Identify	Used to indicate the end of a nultiple byte message.
6	DAV	Data Available	Is asserted TRUE by the sender of data when NRFD goes TRUE, remains TRUE until NDAC is sent TRUE by the data receiver.
7	NRFD	Not Ready For Data	When all devices are ready to receive data this line goes high. Remains high until DAV is sent TRUE.
8	NDAC	Not Data Accepted	When all receiving devices are through with the data on the bus, this line goes high, indicating that the sender may remove the data and set DAV low. When DAV goes to the receiving devices then pull NDAC low again.
9	IFC	Interface Clear	Sent high by the controller. It places all device interfaces in a known quiescent state.
10	SRQ	Service Request	This line is used by any device to get the attention of the controller.
11	ATN	Attention	Used by the controller to notify all other devices what type of message (interface versus device dependent) is on the data bus. When ATN is TRUE, messages sent are interface messages and all devices capable of receiving messages must handshake the transfer. When false, device dependent messages are sent and only devices that have been addressed remain active.
12		Shield*	Surrounds all conductors.
17	REN	Remote Enable	Must be TRUE to place instruments into remote. Once in Remote, if REN goes false all instruments must go to local.
18	GND	Return for DAV	
19	GND	Return for NRFD	
20	GND	Return for NDAC	
21	GND	Return for IFC	
22	GND	Return for SRQ	
23	GND	Return for ATN	
24	GND	Logic common for DIO 1-DIO 8, EOI, and REN	

**The cable shield is routed to a banana jack on the rear of the Option –05 interface adjacent to the programming conductor. This banana jack may be tied to the DMM chassis ground post located on the rear panel. However, caution must be exercised to prevent ground loops in the system.*

Table 605-4. Interface Messages

MNEMONIC	MESSAGE	CODING			ALL DEVICES RESPOND (Universal)	ADDRESSED DEVICES ONLY RESPOND	DEVICE IN LOCAL RESPONDS AND GOES TO REMOTE	NOTE
		BINARY	OCTAL	HEX				
MLA	My Listen Address	X F T A5 A4 A3 A2 A1				X	X	1
MTA	My Talk Address	X T F A5 A4 A3 A2 A1				X	X	1
UNL	Unlisten	X F T T T T T T	077	3F	X			
UNT	Untalk	X T F T T T T T	137	5F	X		X	
OTA	Other Talk Address	X X X X X X X X					X	2
SPE	Serial Poll Enable	X F F T T F F F	030	18	X		X	
SPD	Serial Poll Disable	X F F T T F F T	031	19	X		X	
LLO	Local Lockout	X F F T F F F T	021	11	X		X	
GTL	Go To Local	X F F F F F F T	001	01		X		
DCL	Device Clear	X F F T F T F F	024	14	X			
SDO	Selected Clear	X F F F F T F F	004	04		X		

605-25. Resets

605-26. Power-on or software resets may occur. At power-on, U8(PB)-10 causes an interface reset to prevent unwanted states in the interface logic. Software resets, decoded by U13(PB)-6, may occur as a result of a momentary power interruption, a front panel request, or a system request.

605-27. Control Register

605-28. The following six "D" flip-flops compose the control register:

1. Interrupt enable U14(PB)-2 remains true, except during the power-on routine.
2. A service request (SRQ) to the system controller is initiated by U14(PB)-13.
3. The instrument controller being ready for data (RFD) is indicated by U16(PB)-1.
4. At the last data byte of a message to the system from the instrument controller, U11(PB)-13 goes true.
5. Data accepted (DAC) is sent and RFD is reset by U16(PB-13.
6. When the instrument is a talker, U11(PB)-2 is used to generate the data available (DAV) signal.

605-29. Status Register

605-30. The status register consists of U28 and part of U31. The instrument address decoded by U13(PB)-9 enables a status byte to be placed on the data bus (ID0-ID7). This status byte is defined as follows:

1. ID0: true from U28-7 when in the talk only mode.
2. ID1: true from U28-9 when remote enable (REN) from the system controller is false.
3. ID2: true from U28-9 when go to local (GTL) is true from the message decoder U5-4.
4. ID3: true from U28-3 for an interface message.
5. ID4: true from U31-3 for an interface message.
6. ID5: true from U31-5 to indicate a device dependent message.
7. ID6: true from U31-7 during the serial poll mode when the system controller is requesting status.
8. ID7: true from U31-9 when the system controller is requesting data from the instrument.

605-31. Message Decoder

605-32. Interface messages sent by the system controller on the data bus are decoded by U9, U5 and U8. The device dependent messages GET, SCD and GTL require the interface to be a listener before the instrument controller is interrupted. For group execute trigger (GET), U8-11 is true. For selected device clear (SDC), U8-10 is true. For go to local (GTL), U5-4 is true. The universal messages DCL and LLO are unique in that they cause the instrument controller to be interrupted when in local. For local lockout (LLO), U5-3 is true. For device clear (DCL), U5-10 is true. In addition, U8-4 goes true for the serial poll mode (SPE), and U8-3 is true for serial poll disable (SPD).

605-33. Mode Register

605-34. The mode register consists of the following four J-K flip-flops: U11-1 (clocks in MLA), U11-15 (clocks in MTA), U15-1 (true in remote mode) and U15-15 (true in serial poll mode).

605-35. Instrument Interrupts

605-36. Except during the power-on routine, interrupts are enabled by U14(PB)-2. The interrupt flip-flop may be clocked by the DAV signal through U4(PB)-4 and U4(PB)-3 or by U6(PB)-13 when the instrument is to be an active talker.

605-37. MAINTENANCE

605-38. Refer to Section 4 of the Instruction Manual for information on cleaning the module. The two pcb's are disassembled by removing the screws and standoffs fastening them together. To prevent damage to the electrical connectors, pull the boards straight apart.

605-39. PERFORMANCE TEST

605-40. Operation of the IEEE Interface can be verified by programming changes in range, output and mode, and by observing response data.

605-41. CALIBRATION

605-42. The IEEE Interface does not require calibration.

605-43. TROUBLESHOOTING

605-44. Troubleshooting the -05 IEEE Remote Interface Option consists of the tabular flow chart in Table 605-5. When a step in the flow chart is completed, check for a decision transfer, If no decision is required, perform the next step of the table in sequence.

605-45. Programming Instructions

605-46. Programming commands and instrument responses are explained in Table 605-6.

605-47. PARTS LIST

605-48. Table 605-7 provides a detailed parts list for the Interface PCB; Table 605-8 lists parts for the Piggyback PCB. Refer to Section 5 of this manual for ordering information.

Table 605-5. Troubleshooting

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
	NOTE *Due to the speed and complexity of the data on the bus system, it is recommeded that the pcb be sent to the nearest Fluke Service Center for repair when a problem is isolated to the interface. The following table will be of some assistance when troubleshooting simpler problems; however, manu many problems will require the use of a Fluke Trendar, or similar logic board tester. The instrument must be connected through a bus network to a system controller, e.g., the Tektronix 4051 or HP 9825, to operate.*		
1	This test is based on the assumption that the DMM was checked and found opeational in local operation prior to installation of the IEEE Interface.		
2	Install the IEEE Interface Assembly in the instrument and apply power from the front panel switch.		
3	Is the front panel display correct?	6	4
4	If the display is blank, check the ACK circuit on the PB PCB.		
5	If the display is incorrect, check the input latches and output buffers on the Main PCB. Repair as required and return to step 2.		
6	Address the instrument on the IEEE bus with the applicable address. Does the instrument go into remote?	8	7
7	On the Main Board check the address lines through the Receiver/Driver, the address switches, the MLA circuitry, and the REN and DAV signals. On the Piggyback Board check the INT circuit. Repair as required then resume at step 2.		
8	Program an instruction from the remote controller. Is the output display as programmed?	10	9
9	Check the output latches and buffers, the UNL circuitry and the Receiver/Driver on the Main Board. Repair as required and return to step 8.		
10	Does the instrument respond to and "SRQ" from an Interrupt Ready or Error?	12	11
11	Check the SRQ line inand the Receiver/Driver on the Main Board and the status latches on the Piggyback Board. Repair as required then resume at step 10.		
12	Does the interface clear from the system controller?	14	13
13	Check the IFC input and the IFC circuit. Repair as required, then resume at step 12.		
14	Can the Front Panel be locked out from the system controller?	16	15
15	Check the LLO line and the decoder circuit. Repair as required then resume at step 14.		
16	Troubleshooting of the IEEE Interface, as applicable at this level, is complete.		

Table 605-6. Programming Instructions

The programming instructions in this table pertain to the 8500 Series Digital Multimeters with the IEEE-488 Interface (Option -05), the Bit Serial Interface (Option -06) or the Parallel Interface (Option -07) installed. Features and instructions unique to the DMM model or to the Interface used will be identified in the following manner:

1. 8500A or 8502A: the symbol ◆ will denote an explanation applicable to one DMM model only. The software version incorporated in the DMM may also be mentioned for further identification. To verify the software version incorporated in your instrument, observe the display indication at power on or reset. For example, in the 8502A, "HI-2.0.2" will appear in the display for models with software version 2.0.2.

2. -05, -06, or -07 Interface Options: the symbol ● will be used with a feature or instruction unique to a particular Interface.

INITIALIZATION

When power is applied, or the Reset character (*) is transmitted, the instrument assumes a preset default condition. This condition is defined by the following remote codes:

	REMOTE CODE	COMMAND
	V	Volts DC
	R4	1000V range
◆	S5 (8500A)	2^5 Samples per Reading
◆	S7 (8502A)	2^7 Samples per Reading
	F0	Fast Filter, Timeout Disabled (Panel Indicator OFF)
	X0	External Reference/Scaling Disabled
	P0	Offset Feature Disabled
	U0	Limits-Peak Value Storage Disabled
	T0	Single Reading Line Synchronous
	B0	Single Character ASCII Format
	D0	Front Panel Display Active
	L0	Deactivate Local Lockout
	J0	Deactivate Line Feed Suppression
	M0	Enable Cal Memory Factors
◆	Q0 (8502A)	Disable External Trigger
◆	W (8502A)	No Delay
●	Y0 (-06 Option only)	Echo mode off (Bit Serial IF)

In addition, the following instrument states are assumed at power on or Reset:

	Remote/Local	Local
	Offset	Zeroed
	V dc Zero	Zeroed or *
	Ohms Zero	Zeroed or *
	Cal Memory Factors	*
	Peak Values	Cleared
	Limits Values	Zeroed
	Ext. Ref/Scaling Values	1
●	8/16 Bit Mode (-07 Option only)	8 Bit

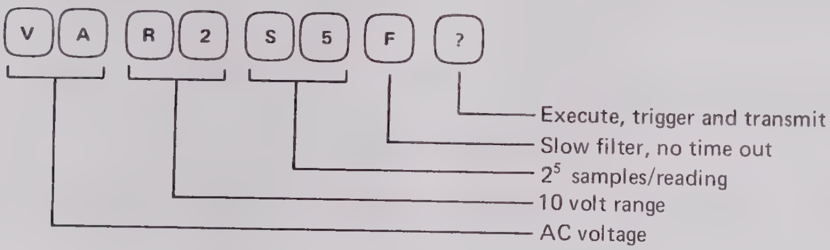
*Retained if Cal Memory Option -04 installed

Table 605-6. Programming Instructions (cont)

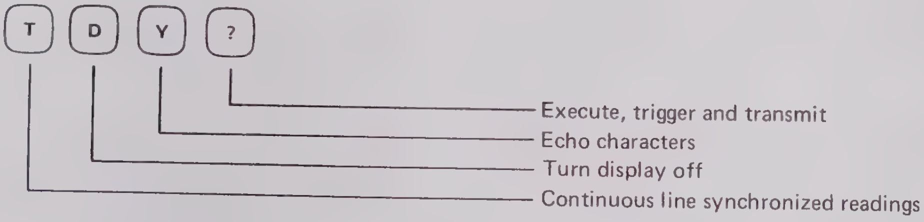
PROGRAM SEQUENCE

When equipped with a remote interface option, the instrument is programmed through a sequence of commands ("command string") that will determine range, function, reading rate, etc. Examples of 5 possible command strings are:

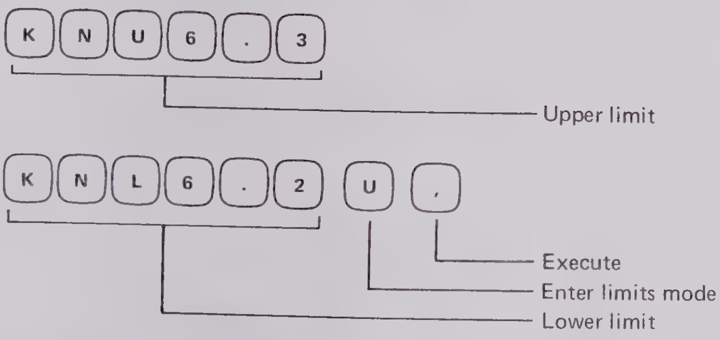
1.


V A R 2 S 5 F ?
Execute, trigger and transmit
Slow filter, no time out
2⁵ samples/reading
10 volt range
AC voltage

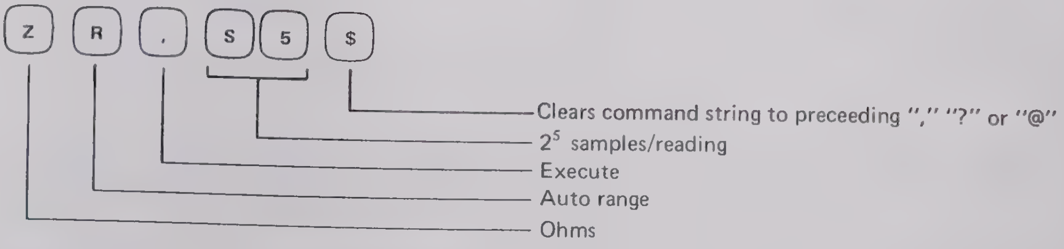
2.


T D Y ?
Execute, trigger and transmit
Echo characters
Turn display off
Continuous line synchronized readings

3.


K N U 6 . 3
Upper limit
K N L 6 . 2 U ,
Execute
Enter limits mode
Lower limit

4.


Z R , S 5 $
Clears command string to preceeding "," "?" or "@"
2⁵ samples/reading
Execute
Auto range
Ohms

5.

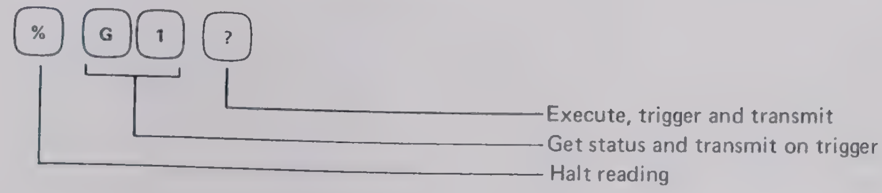

% G 1 ?
Execute, trigger and transmit
Get status and transmit on trigger
Halt reading

Table 605-6. Programming Instructions (cont)

All command string characters transmitted via the remote interface must be ASCII 7-bit upper case characters. A command string is a sequence of 1 to 31 characters. Characters are classified as immediate, command or termination. The instrument may be placed in Remote mode by toggling the front panel REMOTE switch or by transmitting any character that the instrument will recognize from the remote controlling terminal.

● With the IEEE Interface installed, the REMOTE switch can only be used to select local mode if already in Remote.

REMOTE is the only front panel switch to remain active when in REMOTE mode; REMOTE may, however, be locked out by the local lockout command.

IMMEDIATE CHARACTERS

There are 5 immediate characters; each of these may be executed at any time and does not require a termination character.

*	**Reset**	This immediate character will reset the instrument to the conditions described under INITIALIZATION. ◆ When transmitted, the reset character must not be followed by any other character for 3 seconds with the 8502A (2 seconds with the 8500A). Any carriage return or line feed following the reset character must be suppressed. The remote interface will be unable to accept programming characters during this time.
%	**Halt**	The halt character is used to terminate the continuous mode and cause the instrument to wait for a command string. No other characters should precede the halt character if continuous mode is in effect. Upon receipt of the halt character, the transmission of readings is terminated immediately. The following trigger mode transitions will occur when halt is used: From: Continuous Line Synchronous To: Signal Reading Line Synchronous From: Continuous Asynchronous To: Single Reading Asynchronous
#	**Go To Local - Lock Out Remote**	● This character will command the instrument (Options -06 or -07 only) to enter local mode of operation and lock out the remote interface. ● The Remote mode may then be reentered by pressing the front panel REMOTE switch (for Option -06, -07). The Remote mode may not be reentered from the front panel when using the IEEE-488 Interface (Option -05).

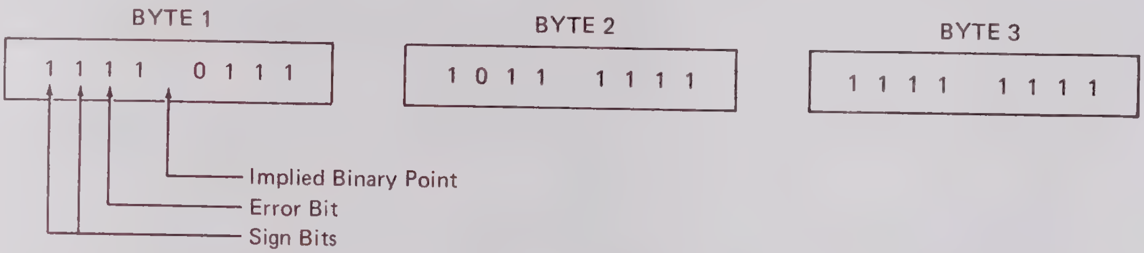
Table 605-6. Programming Instructions (cont)

#	**Go To Local-Lock Out Remote (cont)**	The state of the instrument, when changing from remote to local operation will be modified as follows: 1. Ohms fast mode will be ignored. ◆ 2. Scaling mode will not be in effect (8500A only). ◆ 3. If the high averaged samples per reading rate was in effect, the samples per reading will be set to 2^7 (8500A only). The state of the instrument when changing from local to remote operation will be modified as follows: 1. Ohms fast mode (Z1) and continuous reading mode will be resumed if the DMM was in either mode when place into local. 2. Any error that occurred during local operation will be stored and available for recall.
!	**High Speed Reading Mode**	● The "!" character can be used with the Parallel Interface (Option -07) (and with the IEEE-488 Interface Option -05 in the 8502A only). The High Speed Reading mode provides a shortened 3-byte binary two's complement format response representing the input to the DMM's A/D Converter. Speeds up to 500 readings per second are possible in this mode of operation. True readings can be computed from this response using range and function dependent factors (refer to Fluke Application Bulletin 25). The High Speed Reading mode is suited to systems with very fast processors, to use with stored readings, or to applications not requiring direct numeric conversions (e.g., zero crossings or large deviations from a nominal value). ◆ Use of the "!" character will place the DMM in the High Speed Reading mode and trigger the first reading. Subsequent readings can be triggered by sending the "?" character. In addition, for the 8502A equipped with the -08A Option, subsequent readings can be triggered by sending the TTL pulse with the External Triggering Mode ("Q" or "Q1"). The High Speed Reading mode can be aborted at any time by transmitting a character other than "?" when a reading is to be triggered. The character sent in this case will do nothing more than cause the DMM to exit the High Speed Reading mode.

Table 605-6. Programming Instructions (cont)

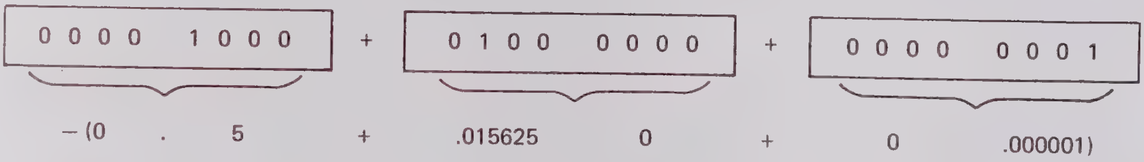
Voltage and Current Reading in "!"

The response data from the DMM will be in 3-byte format, as shown below, for each voltage or current reading. The first byte of this response contains sign and error bits, an implied binary point, and an implied scale factor of ten. Bytes 2 and 3 further define the reading. If the reading is negative, the sign bits will equal "1", and all three bytes must be two's complemented before conversion. If the error bit is equal to the complement of the sign bit, an error is defined.



In this example, the sign bits are "1" and the reading is negative. Since the complement of the sign bit does not equal the error bit ("1"), no error is defined.

To convert the response in this example, the two's complement must first be formed.



= 0.515626 X 10 (the implied scale factor)

Further conversion to calculate the true reading Rt necessitates multiplication of the A/D Converter reading (RAD) by the scale factor for the instrument's range and function.

$[R_t = R_{AD} \text{ X Scale Factor}]$

Ohms Readings in "!"

The procedure for measuring ohms in High Speed Reading mode is more complex. High Speed Ohms readings differ from Fast Ohms (Z1) readings; when using the "!" character, the DMM will not compute the true reading. This conversion must be performed by the user. Up to 500 readings a second are possible when using High Speed Ohms. Refer to OPERATING NOTES, provided with Option -05 and -07 for High Speed Ohms Reading procedures.

/

8/16 Bit Toggle

The "/" character is used to toggle between the 8-bit and the 16-bit mode. When this character is used to toggle from one mode to another, the immmediate and/or termination character must be placed in the least significant byte (LSB) of the programming word.

Table 605-6. Programming Instructions (cont)

TERMINATION CHARACTERS

Termination characters cause the execution of a command string. They are normally placed at the end of each programming statement.

$	**Clear the Command String**	●	(Normally used only with the Bit-Serial Interface -06 Option.) This character is used to erase an incorrect programming entry from the command string buffer, deleting all characters issued back to, but not including, the preceding termination character. A new command string is then needed to modify the state of the instrument.
,	**Execute the Command String**		This character is used to cause the execution of the previous command string. The instrument will then be in the defined state only; the character will not trigger a reading or produce a response from the instrument. When programming a string of characters, it is recommended that the execute character be used at frequent intervals; if an error is made, the string need then be cleared only back to the last execute character. This execute character is also required if a command string longer than 31 characters is used.
?	**Execute the Command String and Trigger**		This character will cause three actions: any previously entered command string will be executed, a reading will be taken, and that reading will be transmitted through the remote interface. If a command string was not entered immediately preceding this character, the instrument will take and transmit a reading in the last defined state. An exception occurs when a command string containing a "Get" command has been entered; the instrument will then respond with the value or status that was requested by the command string (no reading will be triggered). When issuing a program string terminated by the "?" character, the "CR" and/or "LF" delimiter characters should be, but do not have to be suppressed. If an error occurs during the reading, a single "0", followed by a "CR", will be transmitted. At this point, status should be requested to determine the cause of the error.
@	**Execute, Trigger, and Interrupt when Ready**		This character is used to trigger a reading and generate an interrupt when the reading is complete.

Table 605-6. Programming Instructions (cont)

@ **Execute, Trigger, and Interrupt when Ready (cont)**

- To provide the interrupt, the Bit-Serial Interface (Option -06) and the Parallel Interface (Option -07) transmit a single "CR". The IEEE-488 Interface (Option -05) provides an interrupt by generating a service request (SRQ).

The reading triggered by the "@" character can be obtained by inserting a "G" (get) command in the following command string (terminated by a "?").

> *The "@" character and the IEEE-488 Bus command "Group Execute Trigger" perform the same function.*

COMMAND CHARACTERS

Command characters are classified within the following five groups:

1. FUNCTION
2. RANGE
3. MODIFIERS
4. CONTROL
5. MEMORY

FUNCTION COMMAND CHARACTERS

There are 7 function command characters. Whenever one of these characters is used, the state of the instrument will be changed as follows:

RANGE	Auto
MODIFIERS	Offset, Scaling, Limits, Peaks modes are turned off; stored values for these modes are retained.
MEMORY, CONTROL	Unchanged

If a function is selected requiring an optional module which is not loaded, the function of the instrument will be undefined, and the error code will be set to 19.

V **DC Volts**

V A **AC Volts**

C **DC Coupled AC Volts**

I **DC Current**

I A **AC Current**

Table 605-6. Programming Instructions (cont)

Z **Ohms**

Z **1** **Fast Ohms**

The Z1 character will place the instrument into the ohms function and the fast ohms mode. In normal ohms operation, the unknown resistor value Rx is computed from the following measurements:

V1-V2: the voltage across an internal precision resistor (Rr)
V0: the voltage across the unknown resistor (Rx).

The value of Rx is then computed with Ohm's Law:

$$Rx = Rr \frac{V0}{V1\text{-}V2}$$

Fast Ohms mode differs in that the value of $\frac{Rr}{(V1\text{-}V2)}$ is stored as a constant. The instrument will the find Rx by measuring V0 and multiplying this constant. The constant will change with a function change, range change or overload condition.

NOTE

Fast ohms ("Z1") differs from HIGH SPEED READING ("!"). When using "!" for ohms measurement, Rx is not computed by the DMM.

RANGE COMMAND CHARACTERS

The nine range commands specify the following maximum values by function.

	DC VOLTS	VA or C AC VOLTS	I or IA DC or AC CURRENT	Z or Z1 OHMS
R	Auto	Auto	Auto	Auto
R 0	312 mV	Auto	312 μA	31.25Ω
R 1	2.5V	2.5V	2.5 mA	250Ω
R 2	20V	20V	20 mA	2 kΩ
R 3	160V	160V	160 mA	32 kΩ
R 4	1200V	1000V	1.28A	256 kΩ
R 5	Auto	Auto	Auto	4.096 MΩ
R 6	Auto	Auto	Auto	32.768 MΩ
R 7	Auto	Auto	Auto	262.144 MΩ

Table 605-6. Programming Instructions (cont)

MODIFIER COMMAND CHARACTERS

SAMPLES PER READING COMMAND CHARACTERS

The modifier command character "S" or "H" specifies the number of samples taken per reading. The times shown for these characters are approximate digitizing times per reading for 60 Hz line synchronous operation in dc volts, ac volts or current function.

S	0	**$2^0 = 1$ Sample/Reading (4 ms)**
S	1	**$2^1 = 2$ Samples/Reading (8 ms)**
S	2	**$2^2 = 4$ Samples/Reading (17 ms)**
S	3	**$2^3 = 8$ Samples/Reading (33 ms)**
S	4	**$2^4 = 16$ Samples/Reading (67 ms)**
S	5	**$2^5 = 32$ Samples/Reading (134 ms)**
S	6	**$2^6 = 64$ Samples/Reading (267 ms)**
S	7	**$2^7 = 128$ Samples/Reading (534 ms)**
H	0	**$2^8 = 256$ Samples/Reading (1.1s)**
H	1	**$2^9 = 512$ Samples/Reading (2.1s)**
H	2	**$2^{10} = 1{,}024$ Samples/Reading (4.3s)**
H	3	**$2^{11} = 2{,}048$ Samples/Reading (8.5s)**
H	4	**$2^{12} = 4{,}096$ Samples/Reading (17.1s)**
H	5	**$2^{13} = 8{,}192$ Samples/Reading (34.1s)**
H	6	**$2^{14} = 16{,}384$ Samples/Reading (68.3s)**
H	7	**$2^{15} = 32{,}768$ Samples/Reading (137s)**
H	8	**$2^{16} = 65{,}536$ Samples/Reading (273s)**
H	9	**$2^{17} = 131{,}072$ Samples/Reading (546s)**

Table 605-6. Programming Instructions (cont)

FILTER COMMAND CHARACTERS

The "F" character is used to specify the type of filtering and the enabling of a time-out (for the filter settling time). This time-out causes a delay between a trigger command received and the actual reading taken. In the continuous trigger modes, the time-out will occur before each reading is initiated. The following "F" modifier command characters are used:

F	**Slow filter, time-out disabled.**
F 0	**Fast filter, time-out disabled.**
F 1	**Bypass filter.**
F 2	**Slow filter, time-out enabled (approximately 500 ms).**
F 3	**Fast filter, time-out enabled (approximately 50 ms).**

TRIGGER COMMAND CHARACTERS

The "T" characters specify the instrument's trigger mode. These characters determine whether samples taken are line synchronous (every 4 or 5 ms) or line asynchronous (approximately every 1.7 ms), whether single or continuous readings are to be taken.

T	**Continuous reading mode/line synchronized.**
T 0	**Single reading mode/line synchronized.**
T 1	**Continuous reading mode/line asynchronous.**
T 2	**Single reading mode/line asynchronous.**

NOTE

When line asynchronous modes are selected, the display will be turned off to save time; the front panel switches are then ignored.

◆ When in the continuous mode, any character (except "%" HALT) will be ignored by the instrument (8502A).

When in the Single Reading mode ("T0" or "T2"),and IEEE Group Execute Trigger command, a "?" or "@" character, or a TTL trigger (for the 8502A-08A) must be sent for each reading.

With the Continuous Reading mode ("T" or "T1"), use of the "GET" command, "?", "@" or a TTL trigger will start continuous readings.

Table 605-6. Programming Instructions (cont)

When each reading is accepted by the instrument controller, the next reading will be started. An exception to this sequence occurs in the "J1" Suppress Output mode; the next reading will now be taken immediately, without waiting for the output to the controller.

NOTE

The front panel display does not update in this mode unless the controller asks for a reading.

Use of the "%" character will halt the Continuous Reading mode and cycle the unit back to the Single Reading mode.

OFFSET COMMAND CHARACTERS

The "P" command characters specify whether an offset will be subtracted from a reading. The offset value may be entered by storing either a previous reading or a numerically entered offset.

◆ When storing readings, the 8500A will store the unprocessed reading, and the 8502A will store the displayed value.

Offset values may range from $\pm 1 \times 10^9$ to $\pm 1 \times 10^{-9}$ (including 0.0).

P **Offset subtracted (ON).**

P O **Offset not subtracted (OFF).**

EXTERNAL REFERENCE AND SCALING COMMAND CHARACTERS

The "X" command characters select External Reference or Scaling mode. Either mode is valid for any function and range. In External Reference mode, readings are divided by the signed magnitude of the external reference voltage. In Scaling mode, readings are divided by a numerically entered scale factor or by a previously read value.

X **External Reference On, Scaling Off**

The "X" External Reference mode uses the external reference voltage (Vxref) to divide the measured voltage. Vxref is measured during each reading cycle.

◆ Minimum Vxref = ±0.0001V or the input divided by the maximum display with the volts range, whichever is greater (8500A only).

◆ For the 8502A, the minimum Vxref is the input divided by 10^9.

Maximum Vxref = ±40V between Ext Ref Hi and Lo terminals, providing neither terminal is greater than ±20V relative to the Sense Lo or Ohms Guard Terminals.

Table 605-6. Programming Instructions (cont)

X 0	**External Reference Off, Scaling Off**	
X 1	**External Reference Off, Scaling On**	The "X1" Scaling mode will divide all readings by a previously taken external reference voltage or by a previously entered numeric scale factor. The read valued may not be used as a scaling factor. *NOTE* *The 8502A can store the external reference voltage and the numerical scale factor separately. The 8500A can only store one or the other, not both.* ◆ Minimum scaling factor = the same as the minimum Vxref, for the 8500A. ◆ For the 8502A minimum = 10^{-9}. Factors less than this will be set to 0, which is not a valid scale factor. Maximum scaling factor = ±100 (8500A), or Input/Max Scale factor $<10^{-9}$ (8502A). *NOTE* *The "X" and "X1" modes are mutually exclusive.*

LIMITS AND PEAKS COMMAND CHARACTERS

The "U" command characters specify selection of Limits or Peaks modes.

U	**Limits Testing On**	When this command character is sent, each instrument reading is compared to upper and lower limits. Limit values must be entered separately with a keep command (refer to KEEP COMMAND CHARACTERS). The output format from the instrument (when given a "G" command) is as follows: "0" is transmitted for a reading within limits. "1" is transmitted for a reading greater than the upper limit. "-1" is transmitted for a reading less than the lower limit. "2" is transmitted if an error occurs (e.g., overranging).
U 0	**Disable Limits and Peak Mode(s)**	
U 1	**Save Highest and Lowest Values (Peaks On)**	Previous peak values are erased from memory whenever the "U1" command character is programmed.

Table 605-6. Programming Instructions (cont)

U 1 **Save Highest and Lowest Values (Peaks On) (cont)**

◆ For the 8500A, storage of limit and peak values are mutually exclusive. For the 8502A, limit and peak values can be held in memory simultaneously.

NOTE

Limits are applied after all other modifier operations (Scaling, Offset, etc.) have been performed.

CONTROL COMMAND CHARACTERS

Output Format

The "B" characters activate binary or ASCII output format.

B **Single Byte Binary Format**

B 0 **Single Byte ASCII Format**

● B 1 **Binary 16-Bit Parallel**

● B 2 **16-Bit Parallel**

"B1","B2" used with Paralled ASCII Interface (Option -07) only.

The front panel DMM display is turned on when the ASCII mode is entered and off when the binary mode is entered.

The Binary Output Format

The binary output format consists of five bytes. The first four bytes comprise a 32-bit binary two's complement fixed point number. An implied binary point for this number is located between the first and second bytes. The first 8-bit byte thus serves as the integer portion. The 24 bits of the next 3 bytes serve as the binary fraction. Additionally, since this format cannot be used to hold the entire range of possible values for the DMM, a fifth byte is used as an exponent. This exponent is a two's complement binary number representing the decimal exponent of the binary fixed point number defined by the first 4 bytes. An exception occurs in Limits testing; the response will then be single byte binary two's complement number.

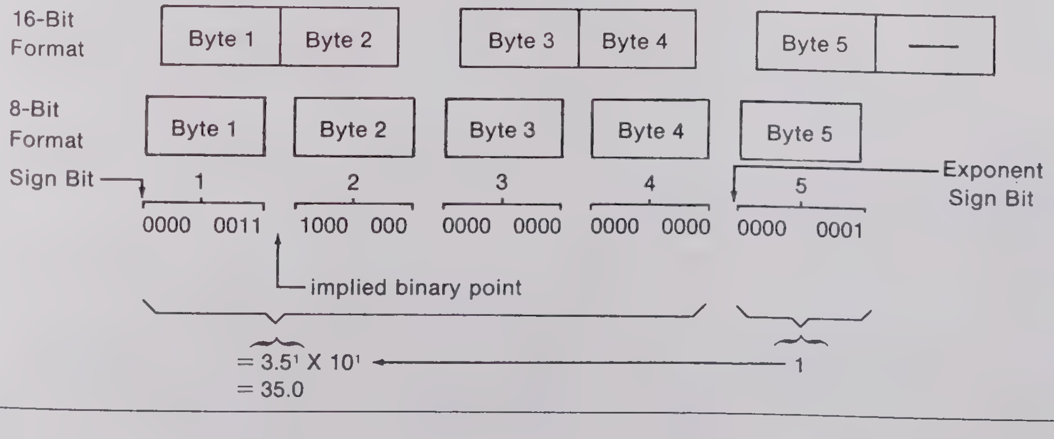

16-Bit Format
Byte 1
Byte 2
Byte 3
Byte 4
Byte 5
——
8-Bit Format
Byte 1
Byte 2
Byte 3
Byte 4
Byte 5
Sign Bit
1
2
3
4
5
Exponent Sign Bit
0000 0011
1000 000
0000 0000
0000 0000
0000 0001
implied binary point
= 3.5¹ X 10¹
= 35.0
1

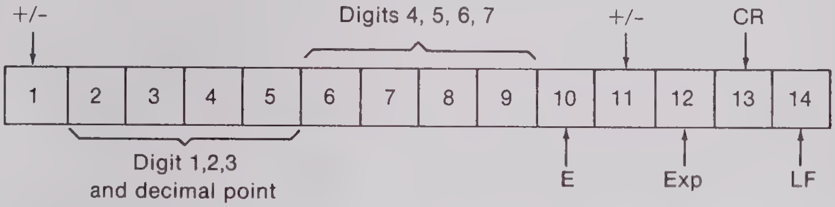
Table 605-6. Programming Instructions (cont)

NOTE

In dc volts and ac volts, the exponent is always 1. In dc and ac current, the exponent is always –2. The exponent is range dependent in ohms function (1 for ohm ranges, 4 for kohm ranges, and 7 for Mohm ranges).

Errors will be indicated by 5 bytes of 0.

ASCII Data Output Format



The seventh digit in the ASCII format corresponds to the "Cal" or HIRES digit of the front panel display. In some ranges and functions (e.g., 100 mV dc) this digit is permanently zeroed since it exceeds the resolution of the instrument). (When in the "Cal" or HIRES mode, the front panel will display the value of the reading rounded to six significant digits.)

DISPLAY CONTROL

The "D" command characters turn the DMM front panel display on or off.

D **Display Off**

D 0 **Display On**

When the "D0" command is used, the instrument will no longer interrogate any of the front panel switches (local lockout). The display will be turned On when the ASCII output format is commanded.

LOCAL LOCKOUT CONTROL

The "L" command characters select the local lockout condition, in which the display remains activated while none of the front panel switches affect the instrument.

L **Local Lockout On**

L 0 **Local Lockout Off**

ECHO COMMAND CHARACTERS

● (used with Bit Serial Option -06 only)

Y **ECHO ON (Full-Duplex)**

Y 0 **ECHO OFF (Half-Duplex)**

Table 605-6. Programming Instructions (cont)

LINE FEED CONTROL COMMAND CHARACTERS

J	**Suppress Line Feed Character**	This character suppresses the LF character normally sent at the end of a response line.
J 0	**Transmit Line Feed Character**	This character disables the "J" character; the "LF" character will be sent.
J 1	**Suppress Output of Readings**	◆ In the 8500A, use of J1 will suppress all output from the DMM. In the 8502A, use of J1 will suppress output with the following exceptions: Service Request (SRQ), status, recalled values. While in the J1 mode, use of the recall command "G ?" will retrieve a reading. Use of "J" or "J0" will exit the "J1" mode.

CALIBRATION CONSTANT

When the Calibration Memory (Option -04) module is installed, the "M" character will inhibit the adjustment of readings by the Calibration Memory correction factor. A slight increase in the speed of readings will result.

M	**Inhibit Calibration Memory Factors**
M 0	**Enable Calibration Memory Factors**

TRIGGER COMMAND CHARACTERS

◆ This set of command characters is available for the 8502A with the Isolator Option -08A.

Q	**Activate External Triggering Mode, Interrupt when Ready**	This character enables the External Triggering mode. Any external TTL trigger then initiates a reading and interrupts when ready (SRQ).
Q 0	**Deactivate External Triggering Mode**	
Q 1	**Activate External Triggering Mode, Transmit when Ready**	The Q1 character also enables External Triggering mode. Any external TTL trigger initiates and transmits a reading.

NOTE

The "?" and "@" characters remain operative during External Triggering.

Table 605-6. Programming Instructions (cont)

◆ EXTERNAL TRIGGER DELAY COMMAND CHARACTERS

(-08A with 8502A only)

The "W" command characters select the amount of delay between the external trigger signal and the initiation of the reading.

W	**No Delay**
W 0	**2.083 ms**
W 1	**4.166 ms**
W 2	**8.332 ms**
W 3	**16.66 ms**
W 4	**33.33 ms**
W 5	**66.66 ms**
W 6	**133.3 ms**
W 7	**266.6 ms**
W 8	**533.2 ms**
W 9	**1.066s**
W 1 0	**2.133s**
W 1 1	**4.266s**
W 1 2	**8.532s**
W 1 3	**17.06s**
W 1 4	**34.13s**
W 1 5	**68.26s**

Table 605-6. Programming Instructions (cont)

MEMORY COMMAND CHARACTERS

STORE

The "K" (Keep) command characters specify the storing of a reading or numeric entry.

K	**Store Last Reading as Offset**	◆ The 8500A will store the unprocessed reading, whereas the 8502A will store the displayed reading.
K 0	**Store Last Voltage Taken as VDC Zero (on R0 Only)**	
K 1	**Store Last Reading as Ohms Zero (on R0 Only)**	
K N P	**Store Numeric Value Following as Offset**	
K N X	**Store Numeric Value Following as Scaling Factor** *(Note: The read value may not be stored as a Scaling Factor.)*	
K N U	**Store Numeric Value Following as Upper Limit**	
K N L	**Store Numeric Value Following as Lower Limit**	

Offsets, Scaling Factors, Upper and Lower Limits may be entered via the "KN" command characters, followed by one of the modifier characters "P", "X", "U" or "L" and the numeric value (on ASCII string of numeric characters, and optional sign, decimal point and signed decimal exponent digit in "E" notation).

Examples of legal numeric strings are:

K N P 1 0

Keep Numeric offset of 10.0

K N X 1 0 . 3 E - 1

Keep numeric scaling factor of 10.3 X 10^{-1} or 1.03

K N U 7 . 6 E 4

Keep numeric upper limit of 7.6 X 10^4

K N L - 1 2 3 . 4 5 6 E + 0

Keep numeric lower limit of -123.456

Table 605-6. Programming Instructions (cont)

An example of an illegal numeric string is:

K N X 2 . 0 E - 1 3

Exponent is limited to one signed integer digit, in this case the exponent would be -1 and the "3" would be ignored.

NOTE

Numeric entries are limited to the maximum display value. These values are:

+1.00000 E+9 to +1.00000 E-9, and -1.00000 E -9 to -1.00000 E +9

Numbers less the ±1.00000 E -9 are treated as zero.

RECALL

The "G" (Get) command characters specify the recall of a reading, a numeric entry or a status. Each "Get" command must be followed by a "?" termination character. The following memory "Get" commands may be used:

G **Recall Previous Reading and Send on Next Trigger**

G 0 **Recall DC Zero and Send on Next Trigger**

G 1 **Recall Status and Send on Next Trigger**

Status information from the DMM may be obtained with the command character "G1?". The status response will be returned in the following seven character format.

Error Codes

1	2					

Characters 1 and 2 define error code status. Each error code contains two digits: those codes with a zero for the first digit are related to remote operation only. All other codes contain the same second digit as the DMM's front panel error codes.

	00	No Error
	06	System Error
	07	Illegal Numeric Entry
	08	Remote Command String Error
	09	Remote Overrange/Underrange
	10	V DC Zero/Ohms Zero Error
◆	11	Offset Error (8500A) Store during Overrange (8502A)

Table 605-6. Programming Instructions (cont)

Error Codes (cont)

12	Filter Module Faulty or not installed
13	DC Signal Conditioner Module Faulty or not installed
14	Excessive voltage present at terminals for Ohms/Current Measurement
15	Fast A/D Converter Faulty or not installed
16	Numeric Display Overflow
17	Magnitude of External Reference Input >20V
18	Controller Module Faulty
19	Function Module selected not installed

Range Codes

		3				

The third character of the status response contains the following range information:

0	100 mV dc, 100 μA, 10Ω
1	1V dc, 1V ac, 1 mA, 100Ω
2	10V dc, 10V ac, 10 mA, 1kΩ
3	100V dc, 100V ac, 100 mA, 10 kΩ
4	1000V dc, 1000V ac, 1A, 100 kΩ
5	1 MΩ
6	10 MΩ
7	100 MΩ

Sample Codes

			4			

The fourth status response character contains sample information identified by the following codes:

0	1 Sample per Reading
1	2 Samples per Reading
2	4 Samples per Reading
3	8 Samples per Reading
4	16 Samples per Reading
5	32 Samples per Reading
6	64 Samples per Reading
7	128 Samples per Reading or Greater

Function Codes

				5	<CR>	<LF>

The fifth response character identifies function:

0	DC Volts
1	AC Volts
2	DC Amps
3	AC Amps
4	Ohms
5	DC Coupled AC Volts
7	Function Not Defined

Table 605-6. Programming Instructions (cont)

G N P	**Recall Offset and Send on Next Trigger**
◆ G N X	**Recall External Ref or Scaling Factor and Send on Next Trigger (8500A)** **Recall Scaling Factor (8502A)**
◆ G N R	**Recall External Reference Factor and Send on Next Trigger (8502A)**
G N U	**Recall Upper and Send on Next Trigger**
G N L	**Recall Lower Limit and Send on Next Trigger**

NOTE

The instrument will replay to "GNU" or "GNL" by transmitting the stored limit value.

G N Q	**Recall Lowest (Peak) Value Found and Send on Next Trigger**
G N W	**Recall Highest (Peak) Value Found and Send on Next Trigger**

Table 605-7. IEEE-488-1975 Interface PCB Assembly

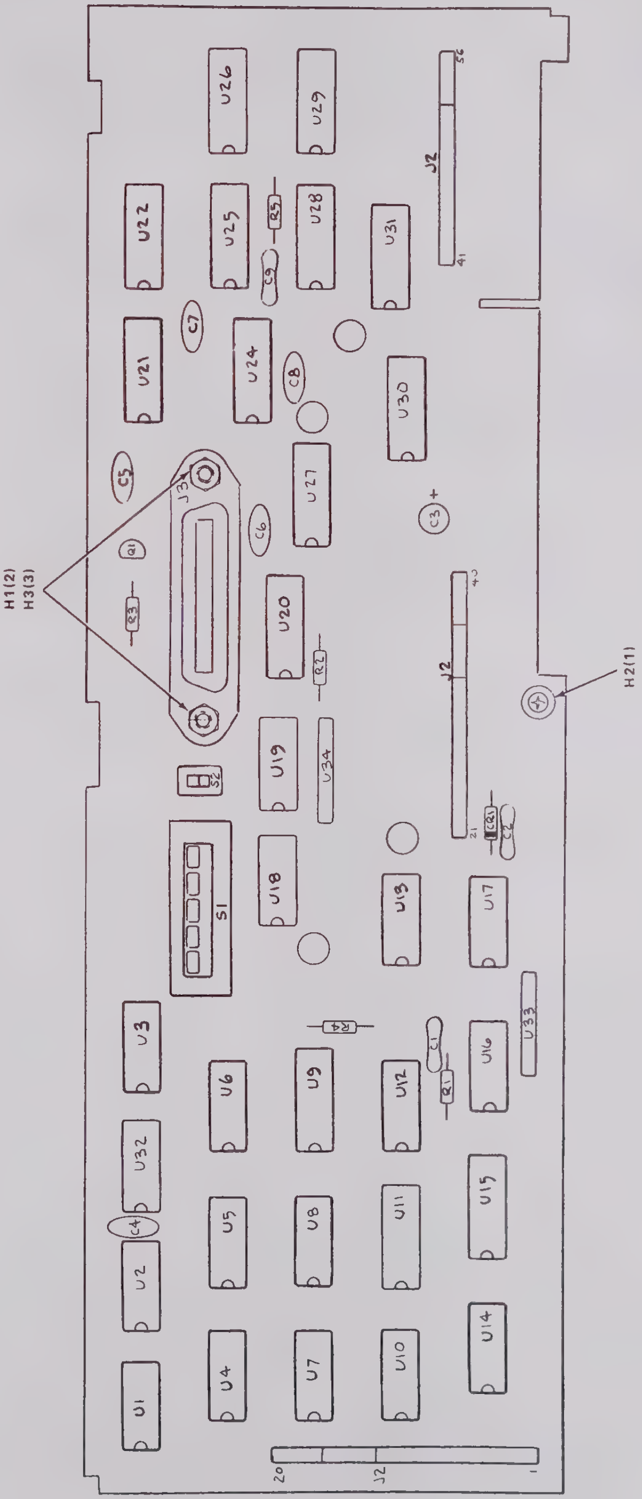
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-05	⊗IEEE 488-1975 INTERFACE PCB ASSEMBLY FIGURE 605-2 (MIS-4172T)	ORDER	BY	OPTION -05			
	IEEE 488-1975 PIGGYBACK PCB ASSEMBLY FIGURE 605-3 (MIS-4074)						2
C1	CAP, MICA, 270 PF +/-5%, 500V	148452	72136	DM15F271J	2		
C2	CAP, MICA, 270 PF +/-5%, 500V	148452	72136	DM15F271J	REF		
C3	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015KA1	1		
C4	CAP, CER, 0.22 UF +/- 20%, 50V	309849	71590	CW30C224K	5		
C5	CAP, CER, 0.22 UF +/- 20%, 50V	309849	71590	CW30C224K	REF		
C6	CAP, CER, 0.22 UF +/- 20%, 50V	309849	71590	CW30C224K	REF		
C7	CAP, CER, 0.22 UF +/- 20%, 50V	309849	71590	CW30C224K	REF		
C8	CAP, CER, 0.22 UF +/- 20%, 50V	309849	71590	CW30C224K	REF		
C9	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	1		
CR1	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	1	1	
H1	LOCKWASHER, SPLIT, 8-32	111070	89536	111070	2		
H2	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		
H3	SCREW, CONN MTG, (USE ON J3)	429472	89536	429472	2		
J2	POST, CONTACT	447813	22526	65501-136	3		
J3	CONN, CABLE, 24-PIN, MODIFIED	534107	89536	534107	1		
MP1	CASE ASSY (INCLUDES MP2-MP8)	458935	89536	458935	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE, MODIFIED	456079	89536	456079	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	441022	89536	441022	REF		
MP6	DECAL, IEEE INTERFACE ASSY	413518	89536	413518	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	COIL, SPRING (NOT SHOWN)	424465	83553	C0120-014-0380	1		
Q1	XSTR, SI, NPN	218396	04713	2N3904	1	1	
R1	RES, DEP. CAR, 18K +/-5%, 1/4W	348862	80031	CR251-4-5P18K	1		
R2	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
R3	RES, DEP CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	1		
R4	RES, DEP CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	1		
R5	RES, DEP CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	1		
S1	SWITCH, MODULE SPDT, 5-POS.	417766	00779	435470-4	1	1	
S2	SWITCH, SLIDE, SPDT	417287	95146	MSS-1040-1	1	1	
U1	⊗IC, C-MOS, QUAD, 2-INPUT NAND GATE	355198	02735	CD4011AE	1	1	
U2	⊗IC, COS/MOS, DUAL, 4-INPUT, NOR GATES	363820	02735	CD4002AE	1	1	
U3	⊗IC, C-MOS, 8-INPUT, NOR GATES	408781	02735	CD4078BE	3	1	
U4	⊗IC, C-MOS, QUAD, 2-INPUT AND GATE	408401	02735	CD4081BE	2	1	
U5	⊗IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	3	1	
U6	⊗IC, C-MOS, 8-INPUT, NOR GATES	408781	02735	CD4078BE	REF		
U7	⊗IC, COS/MOS, TRIPLE, 3-INPUT NOR GATES	355180	02735	CD4025AE	1	1	
U8	⊗IC, COS/MOS, QUAD, 2-INPUT, NOR GATES	355172	02735	CD4001AE	REF		
U9	⊗IC, C-MOS, DCDR/MULTIPLEXER	408369	04713	MC14556CP	1	1	
U10	⊗IC, C-MOS, QUAD, 2-INPUT OR GATE	408393	02735	CD4071BE	1	1	
U11	⊗IC, COS/MOS, DUAL, JK MASTER FLIP FLOP	355230	02735	CD4027AE	2	1	
U12	⊗IC, C-MOS, TRIPLE 3-INPUT NAND GATES	375147	02735	CD4023AE	1	1	

Table 605-7. IEEE-488-1975 Interface PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
U13	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	2	1	
U14	⊗IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	REF		
U15	⊗IC, COS/MOS, DUAL, JK MASTER FLIP FLOP	355230	02735	CD4027AE	REF		
U16	⊗IC, C-MOS, QUAD, 2-INPUT, NAND	404632	02735	CD4093BE	1	1	
U17	⊗IC, C-MOS, QUAD, 2-INPUT AND GATE	408401	02735	CD4081BE	REF		
U18	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	REF		
U19	⊗IC, C-MOS, 8-INPUT, NOR GATES	408781	02735	CD4078BE	REF		
U20	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	4	1	
U21	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	REF		
U22	⊗IC, C-MOS, HEX INVERTER BUFFER	381848	02735	CD4049AE	2	1	
U24	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	REF		
U25	⊗IC, C-MOS, HEX INVERTER BUFFER	381848	02735	CD4049AE	REF		
U26	⊗IC, COS/MOS, QUAD, LOCKED D LATCH	355149	02735	CD4042AE	2	1	
U27	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	REF		
U28	⊗IC, C-MOS, TRI HEX NON INV BUFFERS	407759	12040	MM80C97N	3	1	
U29	⊗IC, COS/MOS, QUAD, LOCKED D LATCH	355149	02735	CD4042AE	REF		
U30	⊗IC, C-MOS, TRI HEX NON INV BUFFERS	407759	12040	MM80C97N	REF		
U31	⊗IC, C-MOS, TRI HEX NON INV BUFFERS	407759	12040	MM80C97N	REF		
U32	IC, TTL, QUAD, 2-INPUT NAND GATES	393033	01295	SN74LS00N	1	1	
U33	RES. NETWORK, 4.7K	412916	89536	412916	2	1	
U34	RES. NETWORK, 4.7K	412916	89536	412916	REF		

1 SEE TABLE 5-17 AT THE END OF SECTION 5.

2 ONE OR THE OTHER WILL BE INSTALLED.


U26
U29
56
J2
41
U22
U25
R5
U28
C9
U31
C7
U21
U24
C8
U30
C5
J3
U27
C6
C3
+
Q1
H1(2)
H3(3)
R3
U20
40
R2
J2
H2(1)
U19
U34
S2
CR1
C2
21
S1
U18
U13
U17
U33
R4
U3
C1
U6
U9
U12
R1
U16
U32
U15
C4
U5
U8
U11
U2
U14
U4
U7
U10
U1
20
J2
1

MIS-1772

Figure 605-2. IEEE-488-1975 Interface PCB Assembly

Table 605-8.. IEEE-488-1975 Piggyback PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-05P	IEEE-488-1975 PIGGY BACK PCB ASSEMBLY FIGURE 605-3 (MIS-4074)	PART	OF	OPTION -05			
C1	CAP, MICA, 270 PF +/-5%, 500V	148452	72136	DM15F271J	2		
C2	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	1		
C3	CAP, TA, 1 UF +/-20%, 35V	161919	56289	196D105X0035JA1	1		
C4	CAP, MICA 270 PF +/-5%, 500V	148452	72136	DM15F271J	REF		
CR1	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	1	1	
H1	WASHER, FLAT, S/S 1/4 INCH (W/P4)	200980	86928	5710-65-16	1		
H2	WASHER, INT LOCK, 1/4 INCH (W/P4)	110817	73734	1308	1		
P2	CONNECTOR, SOCKET, 20 PIN	447110	30035	SK-109-1-20	2		
	CONNECTOR, SOCKET, 16 PIN	447102	20447	SS-109-1-16	1		
P4	BINDING POST	441741	89536	441741	1		
Q1	XSTR, SI, NPN	218396	04713	2N3904	1	1	
Q2	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
R1	RES, DEP CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	3		
R2	RES, DEP CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	2		
R3	RES, DEP CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	2		
R4	RES, DEP CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R5	RES, DEP CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R6	RES, DEP CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	REF		
R7	RES, DEP CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R8	RES, DEP CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	1		
R9	RES, SELECTED AT TEST						
U1	⊗IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	4	1	
U2	⊗IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	2	1	
U3	⊗IC, C-MOS, QUAD, 2-INPUT NAND GATE	404632	02735	CD4093BE	1	1	
U4	⊗IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	REF		
U5	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	2	1	
U6	⊗IC, COS/MOS, DUAL, 4-INPUT NOR GATES	363820	02735	CD4002AE	1	1	
U7	⊗IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	REF		
U8	⊗IC, C-MOS, QUAD, 2-INPUT, NAND GATES	355198	02735	CD4011AE	2	1	
U9	⊗IC, C-MOS, QUAD, 2-INPUT, NAND GATES	355198	02735	CD4011AE	REF		
U10	⊗IC, C-MOS, HEX INVERTER BUFFERS	381848	02735	CD4049AE	1	1	
U11	⊗IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	REF		
U12	⊗IC, C-MOS, TRIPLE 3-INPUT AND GATES	408807	02735	CD4073BE	1	1	
U13	⊗IC, C-MOS, TRIPLE 3-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U14	⊗IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	REF		
U16	⊗IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	REF		
U17	⊗IC, C-MOS, TRIPLE 3-INPUT NOR GATES	355180	02735	CD4025AE	1	1	

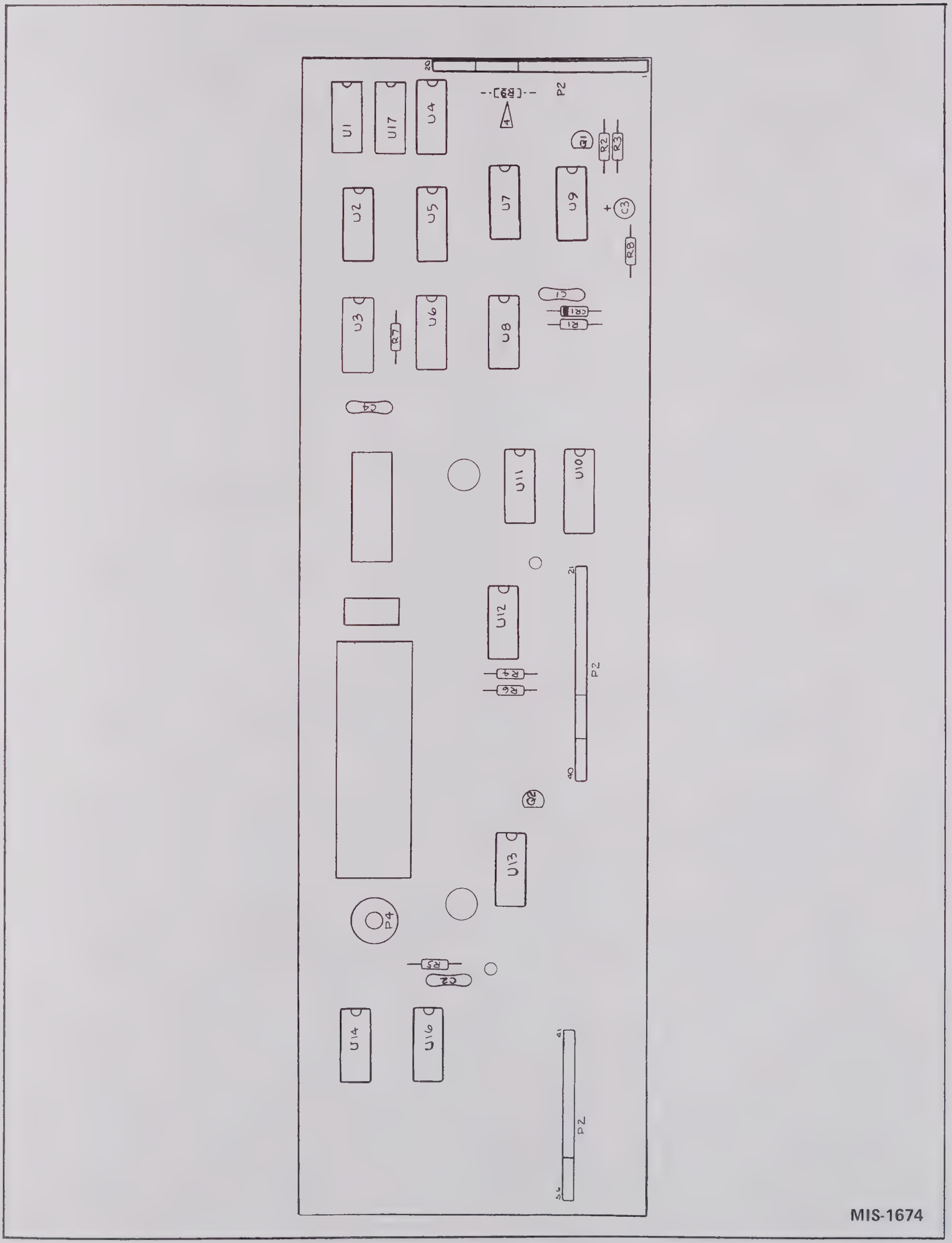
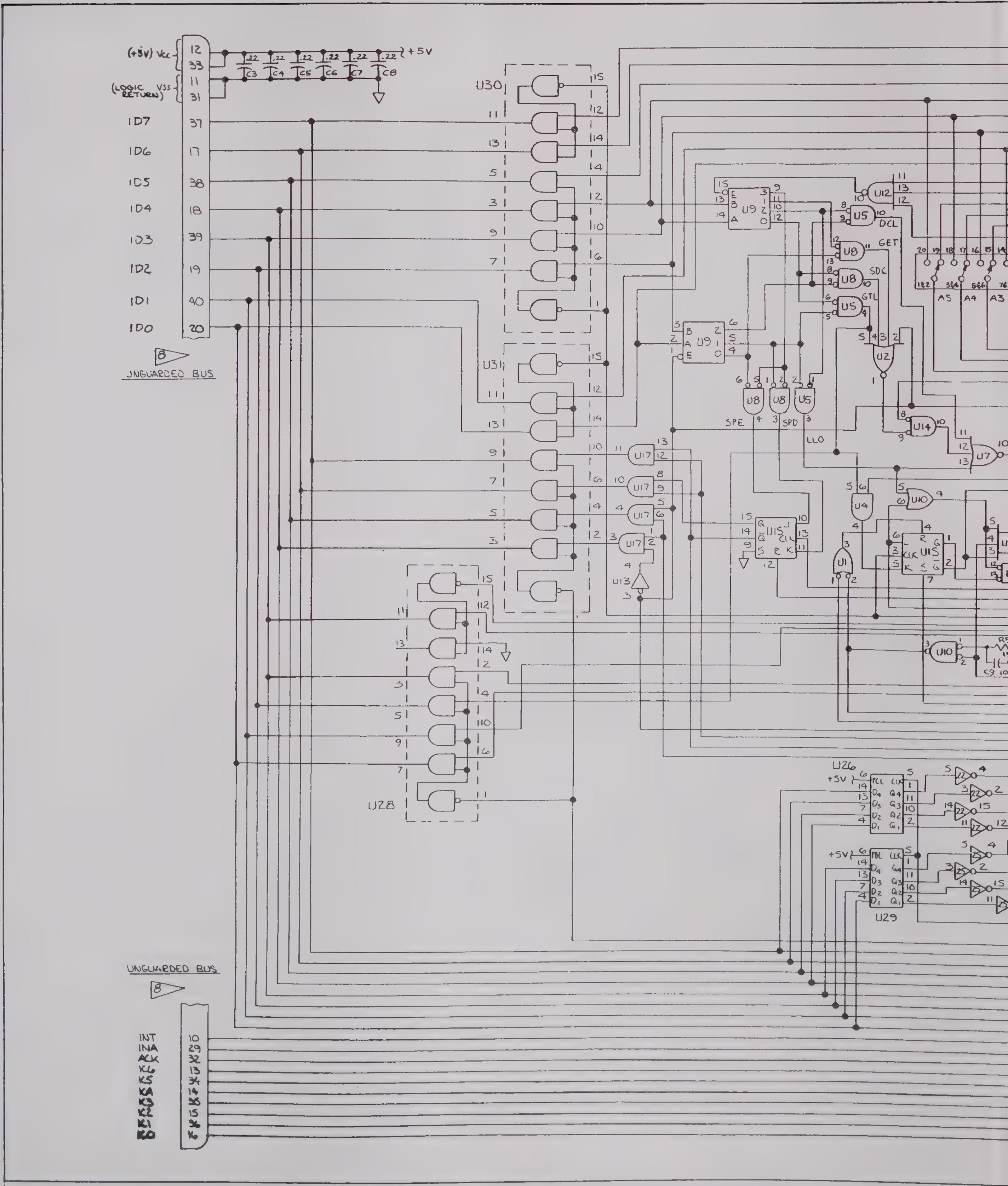
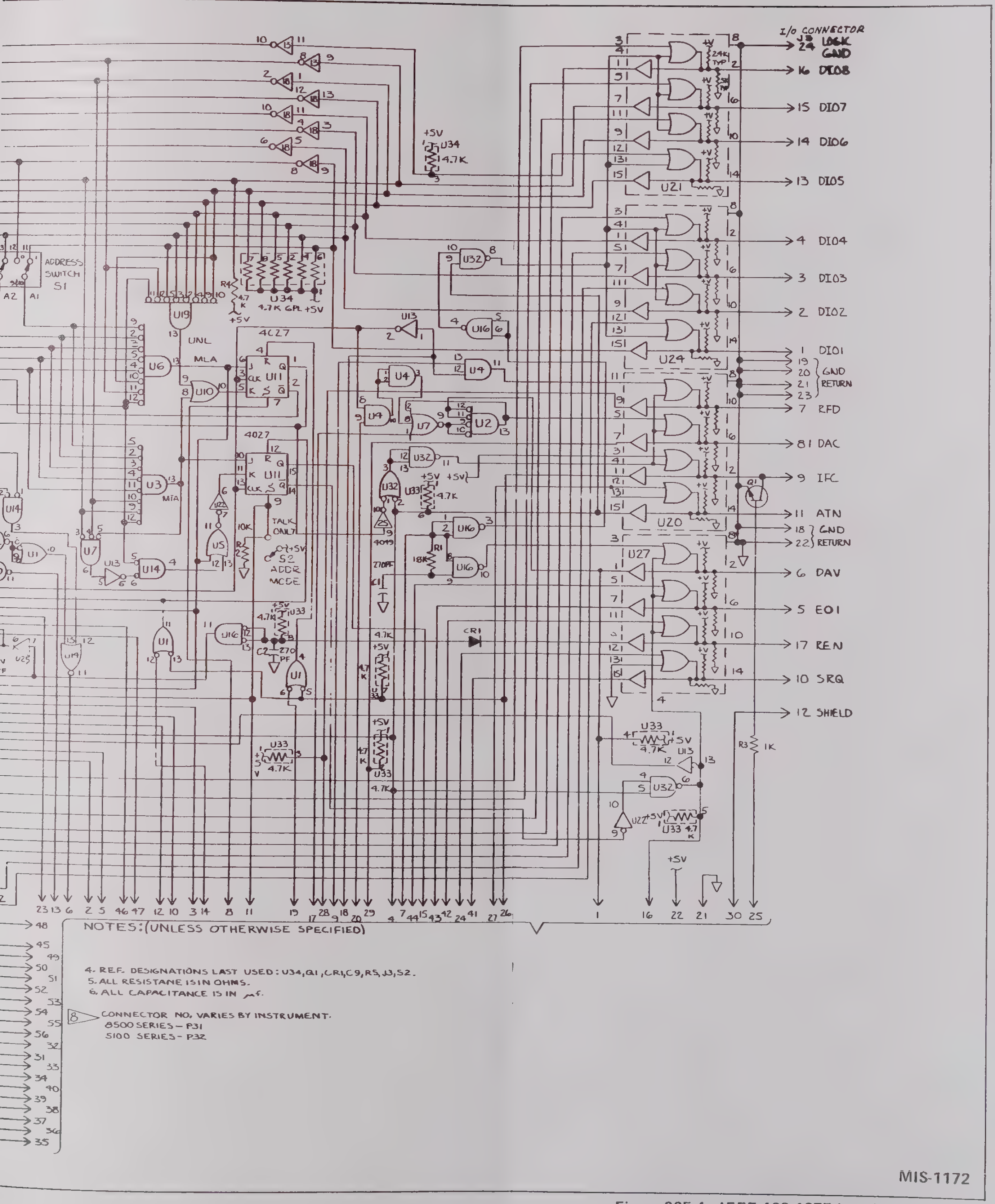

20
1
P2
R9
4
U1
U17
U4
Q1
R2
R3
U2
U5
U7
U9
+
C3
R8
C1
CR1
R1
U3
R7
U6
U8
C4
U11
U10
21
U12
R4
R6
P2
40
Q2
U13
P4
R5
C2
U14
U16
41
P2
56
MIS-1674

Figure 605-3. IEEE-488-1975 Piggyback PCB Assembly


(+5V) Vcc
(LOGIC RETURN) VSS
+5V
C3
C4
C5
C6
C7
C8
.22
ID7
ID6
ID5
ID4
ID3
ID2
ID1
ID0
UNGUARDED BUS
U30
U31
U28
U9
U12
U5
U8
U2
U14
U7
U10
U4
U15
U17
U13
U1
U26
U29
DCL
GET
SDC
GTL
SPE
SPD
LLO
A5
A4
A3
C9
UNGUARDED BUS
INT
INA
ACK
KG
KS
KA
K3
K2
K1
K0


I/O CONNECTOR J3
24 LOGIC GND
16 DIO8
15 DIO7
14 DIO6
13 DIO5
4 DIO4
3 DIO3
2 DIO2
1 DIO1
19 20 21 23 GND RETURN
7 RFD
8 DAC
9 IFC
11 ATN
18 22 GND RETURN
6 DAV
5 EOI
17 REN
10 SRQ
12 SHIELD
U21
U24
U20
U27
U34 4.7K
U34 4.7K 6PL +5V
ADDRESS SWITCH S1
A2 A1
U19
UNL
MLA
MTA
U6
U3
U10
4027
U11
TALK ONLY
S2 ADDR MODE
U32
U16
U13
U4
U7
U2
U33 4.7K
CR1
Q1
R3 1K
R1 18K
C1 270PF
C2 270 PF
U14
U1
U5
U22
U25
+5V

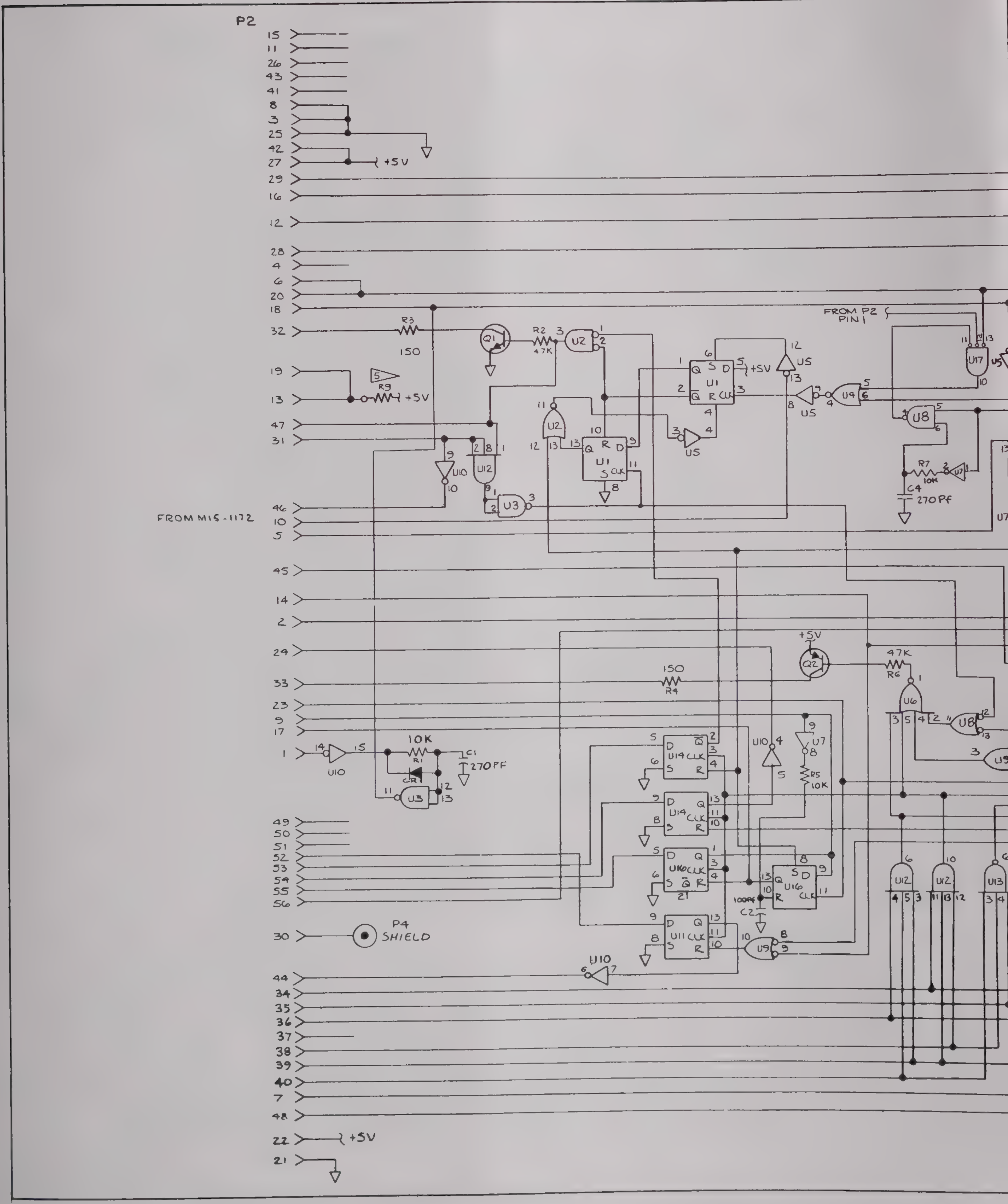
NOTES: (UNLESS OTHERWISE SPECIFIED)

4. REF. DESIGNATIONS LAST USED: U34, Q1, CR1, C9, R5, J3, S2.
5. ALL RESISTANE IS IN OHMS.
6. ALL CAPACITANCE IS IN µf.

8 CONNECTOR NO. VARIES BY INSTRUMENT.
8500 SERIES – P31
5100 SERIES – P32

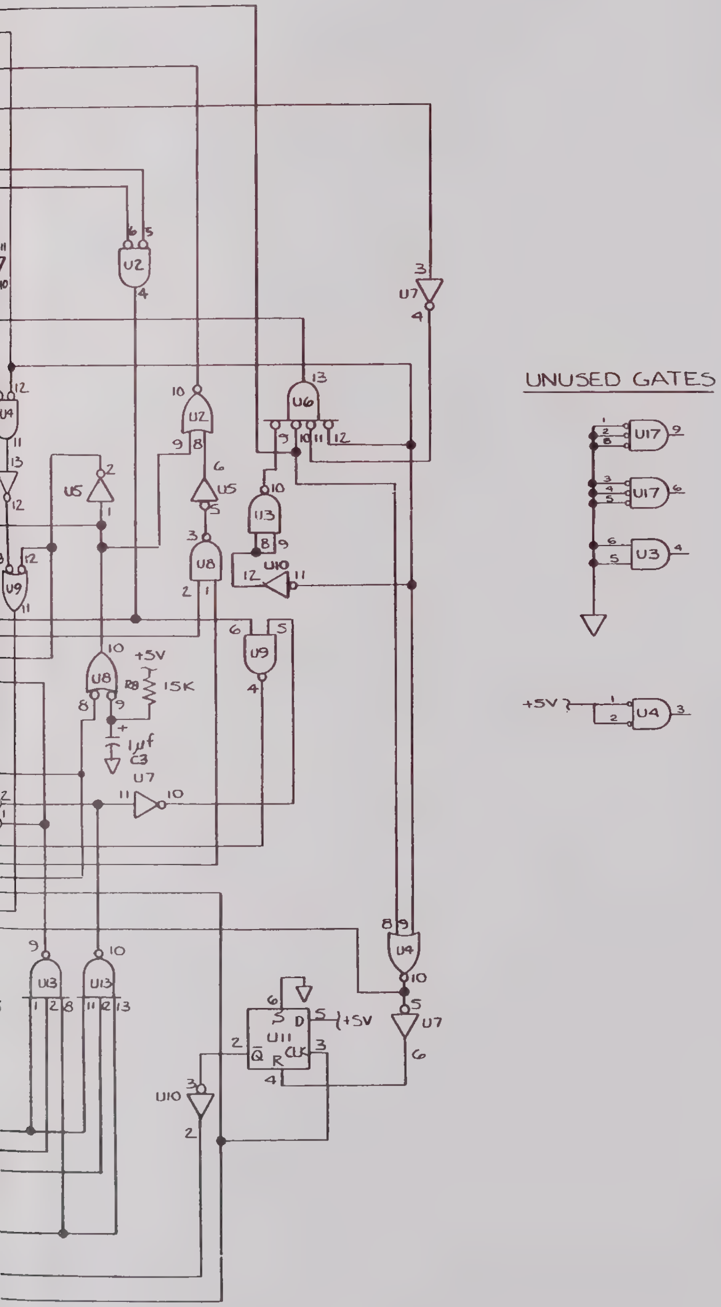
MIS-1172

Figure 605-4. IEEE-488-1975 Interface PCB Assembly


P2
15
11
26
43
41
8
3
25
42
27
+5V
29
16
12
28
4
6
20
18
32
R3
150
Q1
R2
47K
U2
FROM P2 PIN 1
19
13
R9
+5V
47
31
U1
+5V
US
U4
U17
U8
R7
10K
U7
C4
270PF
U10
U12
U3
FROM MIS-1172
46
10
5
45
14
2
24
+5V
Q2
47K
R6
33
150
R4
23
9
17
1
U10
10K
R1
CR1
C1
270PF
U14
U14
U6
U7
R5
10K
U16
U9
49
50
51
52
53
54
55
56
100PF
C2
30
P4
SHIELD
U11
44
34
35
36
37
38
39
40
7
48
22
+5V
21
U12
U12
U13

NOTES: (UNLESS OTHERWISE SPECIFIED).

4. ALL RESISTORS ARE C.C. 1/4W AND RESISTANCE IS IN OHMS.
5 R9 IS TO BE SELECTED AT TEST IF REQUIRED
6. LAST REF. DES. USED: U17, Q2, CR1, R9, C4, P4.
7. REF. DES. NOT USED: U15, P1, P3.


U2
U7
U6
U2
U5
U5
U13
U10
U8
U9
U4
U9
U8
+5V
R8
15K
1µf
C3
U7
U13
U13
U4
U7
U11
D
CLK
R
Q̄
+5V
U10
UNUSED GATES
U17
U17
U3
+5V
U4

MIS-1074

Figure 605-5. IEEE-488-1975 Piggyback PCB Assembly

Option -08A
Isolator (External Trigger)

608A-1. INTRODUCTION

608A-2. The Isolator module maintains the guarded nature of the analog bus by isolating the analog signal processing and converting circuitry from the digital processing, control, display and input/output circuits. An isolator module (either Option -08 or -08A) must be installed whenever a remote interface (Option -05, -06, -07) is used in the 8500 series DMM. The following description pertains to the Isolator Option -08A only. Option -08A provides the capability for external triggering of the DMM. This mode may not be used in instruments which do not have mainframe and motherboard (A2) provisions for external triggering. Digital Multimeter Model 8502A will accept only the -08A Option; Model 8500A will accept the -08, or the -08A without external triggering capability.

608A-3. INSTALLATION

608A-4. Refer to Section 4 of the Instruction Manual for general module installation procedures. The Isolator module (Option -08A) replaces the Interconnect pcb in slot K; slot K can be identified as the only module slot with connectors on both the analog and digital bus lines. The Interconnect Diagram in Section 8 contains a table of slot locations.

608A-5. SPECIFICATIONS

608A-6. Input

608A-7. The trigger input is factory-wired for a high level of 4.3V (minimum) and a low level of 0.7V (maximum); pulse width should be greater than 10 μs. Common will be the same as interface logic common.

608A-8. The outer connector for external triggering is at interface common. There should be no more than 10V between the outer connector and earth ground.

608A-9. Trigger Processing Time

608A-10. The time between trigger edge and first A/D conversion (not including filter timeouts or programmed delays) is:

1. Non-line synchronous mode, .8 to .9 ms
2. Line synchronous mode, 1 to 6 ms
3. High speed mode (Option -05 or -07 installed), 114 ±.5 μs

608A-11. OPERATING NOTES

608A-12. Installation of the Isolator (Option -08A) will not affect standard operation of the instrument. The External Triggering mode may, however, be activated locally from the front panel or through remote interfacing commands.

608A-13. Local Operation

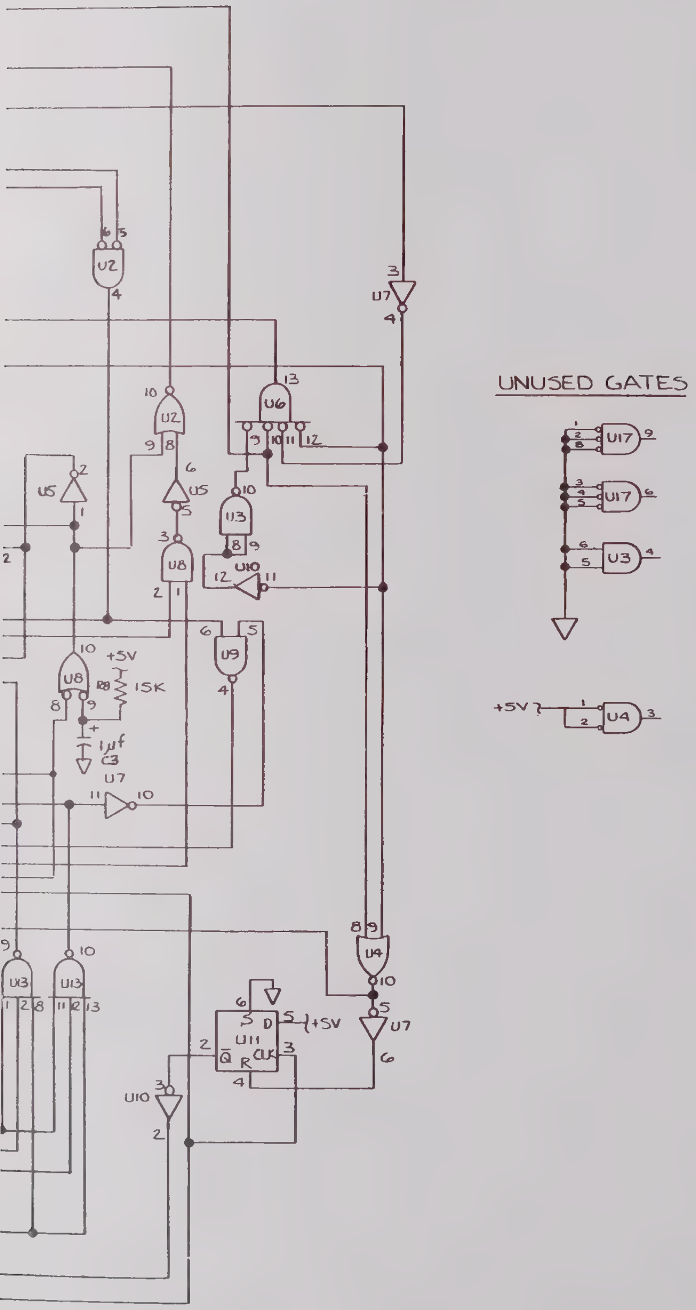
608A-14. The External Triggering mode may be enabled from the DMM's front panel (Option -08A must be installed). To activate this mode, press TRIGGER. The SAMPLE LED will now stop flashing to denote that both External Triggering and Manual Triggering modes are in effect. Apply a negative going TTL level pulse to the external trigger input connector located on the rear panel. The SAMPLE LED will now flash once for each trigger received.

608A-15. The following considerations apply when External Triggering mode is in use:

1. A manual trigger attempted from the front panel will take precedence over an external trigger. If manual TRIGGER is pressed while a reading is in progress, the reading will be aborted and a new one started.
2. All other front panel switch applications will abort the reading in progress. A new reading

NOTES: (UNLESS OTHERWISE SPECIFIED).

4. ALL RESISTORS ARE C.C. 1/4W AND PESISTANCE IS IN OHMS.
5▷ R9 IS TO BE SELECTED AT TEST IF REQUIRED
6. LAST REF. DES. USED: U17, Q2, CR1, R9, C4, P4.
7. REF. DES. NOT USED: U15, P1, P3.


U2
6
5
4
3
U7
4
10
U2
9
8
6
U5
5
U5
2
1
13
U6
9
10
11
12
10
U13
8
9
3
U8
2
1
U10
12
11
6
U9
5
4
10
+5V
U8
R8
15K
8
9
1µf
C3
U7
11
10
UNUSED GATES
U17
9
U17
6
6
5
U3
4
+5V
1
2
U4
3
9
U13
10
U13
8
9
U4
10
5
U7
6
6
S
D
5
+5V
U11
2
Q̄
R
CLK
3
4
U10
3
2

MIS-1074

Figure 605-5. IEEE-488-1975 Piggyback PCB Assembly

Option -08A
Isolator (External Trigger)

608A-1. INTRODUCTION

608A-2. The Isolator module maintains the guarded nature of the analog bus by isolating the analog signal processing and converting circuitry from the digital processing, control, display and input/output circuits. An isolator module (either Option -08 or -08A) must be installed whenever a remote interface (Option -05, -06, -07) is used in the 8500 series DMM. The following description pertains to the Isolator Option -08A only. Option -08A provides the capability for external triggering of the DMM. This mode may not be used in instruments which do not have mainframe and motherboard (A2) provisions for external triggering. Digital Multimeter Model 8502A will accept only the -08A Option; Model 8500A will accept the -08, or the -08A without external triggering capability.

608A-3. INSTALLATION

608A-4. Refer to Section 4 of the Instruction Manual for general module installation procedures. The Isolator module (Option -08A) replaces the Interconnect pcb in slot K; slot K can be identified as the only module slot with connectors on both the analog and digital bus lines. The Interconnect Diagram in Section 8 contains a table of slot locations.

608A-5. SPECIFICATIONS

608A-6. Input

608A-7. The trigger input is factory-wired for a high level of 4.3V (minimum) and a low level of 0.7V (maximum); pulse width should be greater than 10 μs. Common will be the same as interface logic common.

608A-8. The outer connector for external triggering is at interface common. There should be no more than 10V between the outer connector and earth ground.

608A-9. Trigger Processing Time

608A-10. The time between trigger edge and first A/D conversion (not including filter timeouts or programmed delays) is:

1. Non-line synchronous mode, .8 to .9 ms
2. Line synchronous mode, 1 to 6 ms
3. High speed mode (Option -05 or -07 installed), 114 ±.5 μs

608A-11. OPERATING NOTES

608A-12. Installation of the Isolator (Option -08A) will not affect standard operation of the instrument. The External Triggering mode may, however, be activated locally from the front panel or through remote interfacing commands.

608A-13. Local Operation

608A-14. The External Triggering mode may be enabled from the DMM's front panel (Option -08A must be installed). To activate this mode, press TRIGGER. The SAMPLE LED will now stop flashing to denote that both External Triggering and Manual Triggering modes are in effect. Apply a negative going TTL level pulse to the external trigger input connector located on the rear panel. The SAMPLE LED will now flash once for each trigger received.

608A-15. The following considerations apply when External Triggering mode is in use:

1. A manual trigger attempted from the front panel will take precedence over an external trigger. If manual TRIGGER is pressed while a reading is in progress, the reading will be aborted and a new one started.
2. All other front panel switch applications will abort the reading in progress. A new reading

will not start until another trigger is received; the numeric display will not update until the new reading is complete.

608A-16. Remote Operation

608A-17. External Triggering can be enabled and controlled remotely when a remote interface (Option -05, -06, or -07) and the Isolator (Option -08A) are installed. The command characters in Table 608A-1 can be used from the remote.

608A-18. Trigger Polarity

608A-19. Either positive or negative going external triggers may be accepted by the Isolator (Option -08A); factory settings will be for negative triggers. Separate jumper wire arrangements are employed for negative and positive triggers. Refer to Figure 608A-1 for the location of jumper terminals on the Isolator PCB. To change the jumper arrangement, use the following procedure:

1. On the Digital Multimeter (8500 series), press POWER OFF and disconnect the line cord.
2. Remove the Isolator module.
3. Observe Static Sensitive device precautions listed in Section 4 of the Instruction Manual. Avoid touching connector terminals on the Isolator PCB.
4. Remove the Guard Covers from the Isolator PCB using techniques outlined in Section 4 of the Instruction Manual (Module Assembly and Disassembly).
5. For negative going triggers, there will be a jumper between pin 1 and pin 4 on Schmitt Trigger U35.
6. For positive going triggers, remove the jumper between pins 1 and 4 and jumper pin 1 to 2 and 3 to 4 on U35.
7. Reassemble module, replace in Digital Multimeter.

Table 608A-1. Remote Commands

	Ext. Trigger Commands
Q	Ext. Trigger—interrupt when ready
Q1	Ext. Trigger and Transmit Reading
Q0	Disable Ext. Trigger
	External Trigger Delay Commands
W	No Delay
W0	2.083 ms
W1	4.166 ms
W2	8.332 ms
W3	16.66 ms
W4	33.33 ms
W5	66.66 ms
W6	133.3 ms
W7	266.6 ms
W8	533.2 ms
W9	1,066s
W10	2.133s
W11	4.266s
W12	8.532s
W13	17.06s
W14	34.13s
W15	68.26s

608A-20. THEORY OF OPERATION

608A-21. The Isolator accepts parallel data and address bytes, shifts them to serial format for transfer across isolation transformers, and converts them back to parallel format. Seven address (ID) and eight data (ID) lines are used. Lines IC5 and IC6 are always low. The

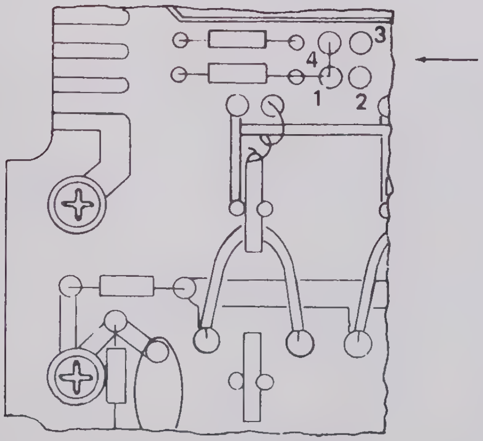


Figure 608A-1. Trigger Polarity Connections

Controller can send data to any addressed module; the A/D Converter will be the only analog module that sends data back to the Controller (bit serial data stream on ID7). Refer to the Isolator Schematic (Figure 608A-3) and the Functional Block Diagram (Figure 608A-2) for the following circuit descriptions.

NOTE

> *When the Isolator is Installed, Vcc and Vss in the unguarded digital bus are isolated from analog common.*

608A-22. The description given in this paragraph will detail how data (ID0-ID7) and address (IC0-IC4) levels on the unguarded digital bus are loaded into shift registers (U3 and U7) in the Isolator. Inputs on address lines IC0-4 for either direct or indirect addresses are applied through inverters to shift register U7. Inputs on data lines (ID0-7) are applied to U7 (ID0, ID1) and U3 (ID2-7). A low on U14-12 will clock both address and data levels into the shift registers; the relaxation oscillator made up of U9-6 and U9-8 will be disabled by this same low during the load time. Monostable multivibrator U14-12 is clocked by a low going signal on U10-12. Two inputs to U10-12 will always be high (IC5, IC6 will always be low and are inverted). The third input will be a high from U10-8, which is enabled with any direct address on IC0-4 (IC0, 3, or 4 will have at least one high). The length of the load time will be determined by R2 and C2.

608A-23. At the end of the load time, relaxation oscillator U9-6 and U9-8 will be enabled, and data will be serially shifted out of registers U3 and U7, across isolation transformers T1 and T2, and into registers U20 and U6. Oscillator pulses from U11-10 and U11-13 clock serial data out of U3 and U7, and into U20 and U16. When this data transfer is complete, U16-11 will go high to enable address gates U22 and U26-4 and disable loading clock pulses to U20 and U16. Parallel data will then be applied through output buffers to ID0-7 on the guarded analog bus. Parallel address levels will be applied through the enabled address gates to address lines IC0-4 on the guarded analog bus.

608A-24. The clock pulse for U9-6 and U9-8 is disabled during the load period (U14-12 low). When clock pulses cease from U24-4, retriggerable monostable multivibrator U23-13 places a low on U20-9 and U16-9 to clear any previously latched data.

608A-25. An acknowledge (ACK) signal is transferred from the guarded analog bus to the unguarded digital bus by way of an isolation transformer. A low at U23-12 will enable U19-1 whenever an ACK is returned. With U19-1 high, a clock pulse from U24-4 and U24-12 is applied through U15-3, U15-6, T8 and T7. This pulse then clocks U8-2, resulting in an ACK signal out on U8-13.

608A-26. In order to obtain a data bit return on ID7, the indirect address is used in three ways. First, the address (IC1, IC2 high) is sent to the A/D Converter

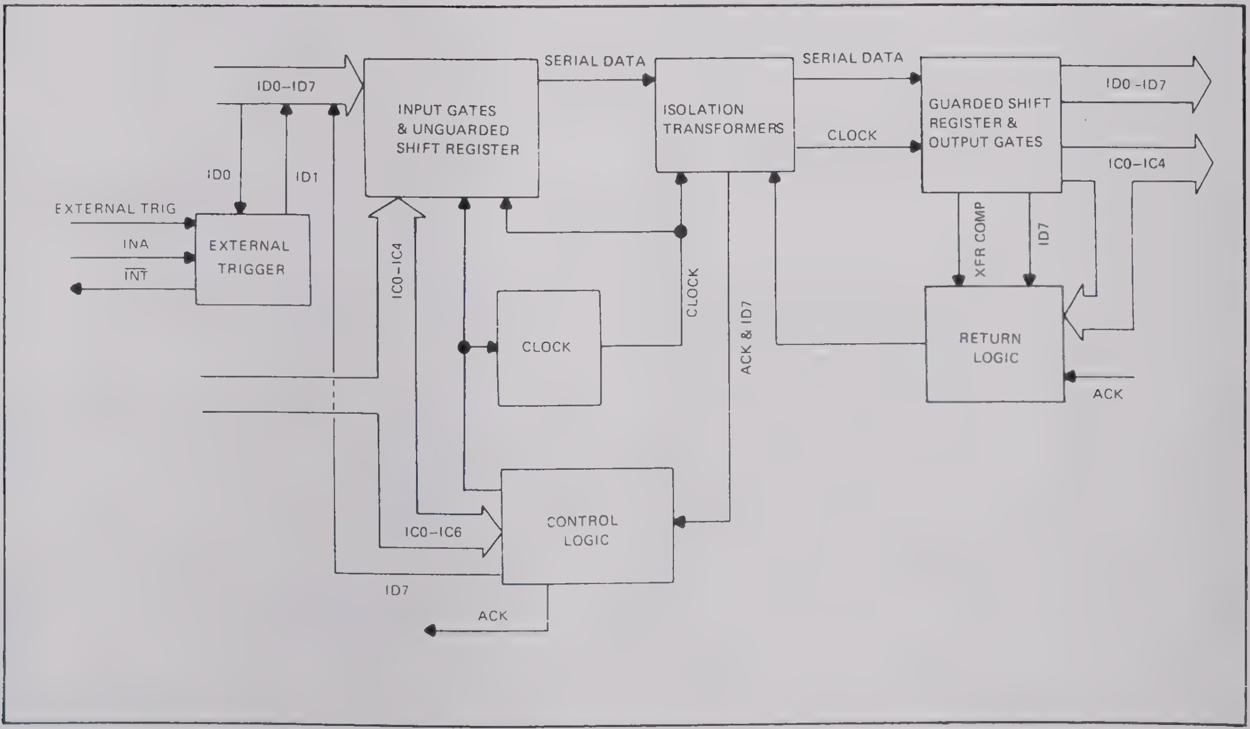


Figure 608A-2. Isolator Block Diagram

through the Isolator's shift register system. The address will also be used to enable U9-11 on the unguarded side of the Isolator. Thirdly, on the Isolator's guarded side, IC1 and IC2 high will enable address decoders U18-4 and U25-9. With U18-3 consequently high, tri-state device U21-13 is placed in the high impedance mode. A path is now enabled for ID7 levels from the guarded analog bus to be transferred back to the unguarded digital bus. For instance, with a high on U19-5, ID7 high will enable U19-4. Clock pulses from U24-4 and U19-4 high enable U15-11 and U15-8. While U9-11 enables U13-9, U8-5 clocked high places ID7 high on the unguarded digital bus.

608A-27. The following sequence of events takes place in the Isolator during external triggering. Dual D flip-flop U31 will be enabled by a low on ID0 and high at U33-9. Address lines IC4, IC5, and IC6 must all be high for U33-9 to go low. With Vcc applied to U31-5, a positive going external trigger from U35-10 will clock U31-1 high. The network of R24 and C6 will detect Vcc at power on and disable the module's interrupt capability. The high at U31-1 sets INT low and places a high at pin 12 of tri-state buffer U13. A returned high on INA then gates U13-11 high onto ID1. The controller will react to this high on ID1 by taking a reading. When data from the reading is accepted, ID0 will again go low, resetting U31 ready for the next external trigger. Triggers received prior to ID0 going low will be ignored.

608A-28. TROUBLESHOOTING

608A-29. Table 608A-2 gives a symptom analysis routine for troubleshooting the Isolator module.

608A-30. PARTS LIST

608A-31. Table 608A-3 gives a detailed parts breakdown of the Isolator (Option -08A). Refer to Section 5 of the Instruction Manual for ordering information.

Table 608A-2. Isolator Troubleshooting

SYMPTOM	POSSIBLE FAILURE
No display at Power On	IC line held low U5, U12, U35
Display Bad	IC line held high U5, U12, U35
	ID line held high or low U1, U2, U13
UNGUARDED SECTION	
Error 9 at Power On	Oscillator check U11-10 Shift Register U31-1, U7 Not transferring pulses U4, core windings ACK bad U9, U12, Q1, U6, U7, U2, U8
Option Configuration Wrong	Address lines hung
Can't Call Proper Ranges	Data lines hung U1, U2, U3
Constant Bad Reading Displayed	ID7 not returned U8, U13, core winding U12, U10, U9, U35, U6.
GUARDED SECTION	
Error 9 or Configuration Wrong	U19-10, U16-1, U23-13 (Address, Data) U25, U19, U15, U24 (ACK) U24, U23 (Address)
Can't Call Proper Ranges	U16, U21, U18
Constant Bad Reading Displayed	U18, U26, U25, U19, U15 (ID7)

Table 608A-3. Isolator PCB Assembly

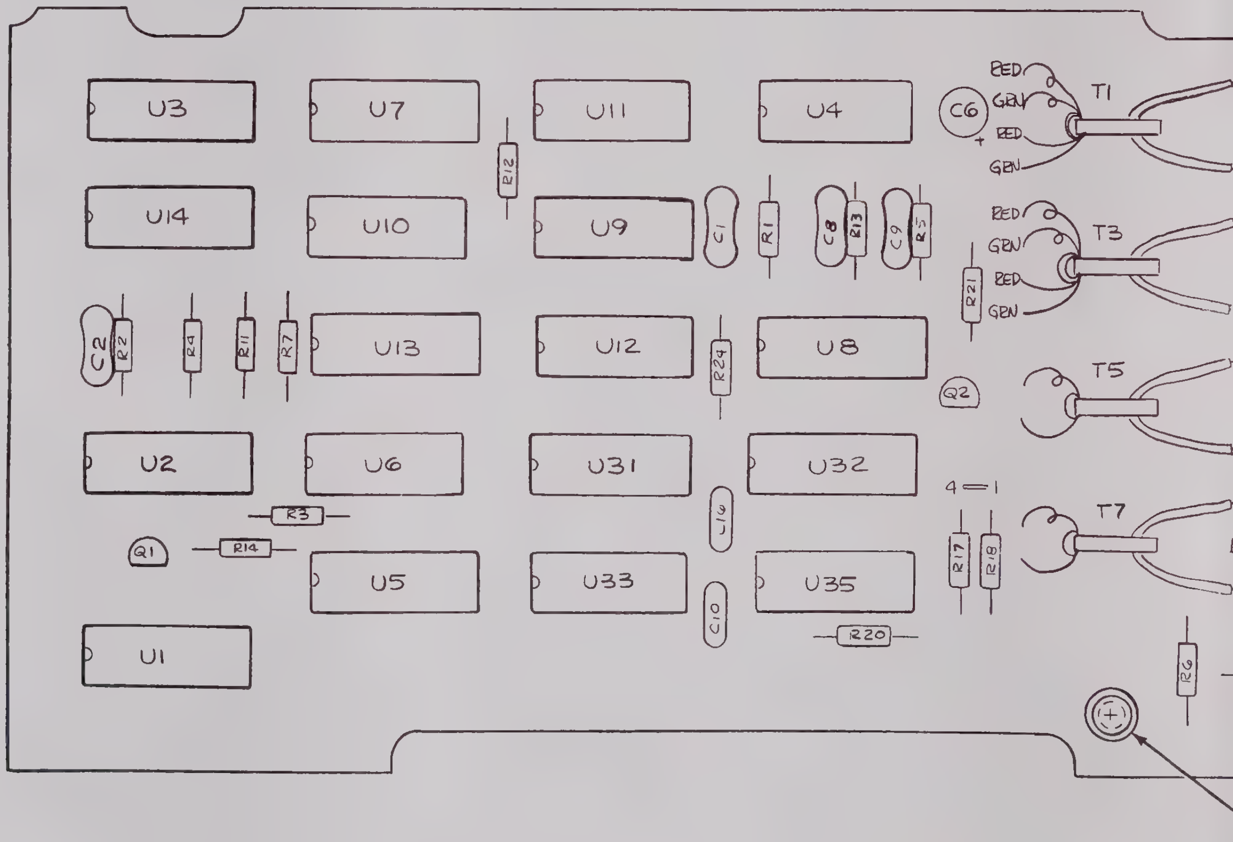
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-08A	⊗ISOLATOR PCB ASSEMBLY FIGURE 608A-3 (8502A-4181T)	ORDER	BY	OPTION -08A			
C1	CAP, MICA, 220 PF +/-5%, 500V	170423	72136	DM15F221J	2		
C2	CAP, MICA, 18 PF +/-5%, 500V	266585	72136	DM15C180J	1		
C3	CAP, MICA, 180 PF +/-5%, 500V	148460	72136	DM15F181J	1		
C4	CAP, MICA, 220 PF +/-5%, 500V	170423	72136	DM15F221J	REF		
C5	CAP, MICA, 68 PF +/-5%, 500V	148510	72136	DM15F680J	1		
C6	CAP, TA, 39 UF +/-20%, 6V	163915	56289	196D396X0006KA1	1		
C7	CAP, ELECT, 150 UF -10/+50%, 16V	186296	73445	ET151X016A5	1		
C8	CAP, MICA, 27 PF +/-5%, 500V	177998	72136	DM15E270J	2		
C9	CAP, MICA, 27 PF +/-5%, 500V	177998	72136	DM15E270J	REF		
C10	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	3		
C11	CAP, CER, 0.0047 UF +/-10%, 500V	106724	71590	CF-472	1		
C12	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C13	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C16	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
H1	SCREW, PHP, 4-40 X 5/8	145813	73734	19027	2		
L1	INDUCTOR, COIL 6-TURN	320911	89536	320911	1		
MP1	CASE ASSY (INCLUDES MP2-MP9)	459024	89536	459024	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE, CASE	486340	89536	486340	REF		
MP5	SHIELD, COVER	437939	89536	437939	REF		
MP6	DECAL, ISOLATOR/EXT TRIGGER	477570	89536	477570	REF		
MP7	DECAL CAUTION	454504	89536	454504	REF		
MP8-1	GUARD, REAR LEFT	437947	89536	437947	REF		
MP8-2	GUARD, REAR RIGHT	383349	89536	383349	REF		
MP9-1	GUARD, FRONT LEFT	487298	89536	487298	REF		
MP9-2	GUARD, FRONT RIGHT	487280	89536	487280	REF		
MP10	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	2		
P43	CABLE ASSY, TRIGGER (NOT SHOWN)	486332	89536	486332	1		
Q1	TRANSISTOR, SI, PNP	226290	04713	MPS3640	1	1	
Q2	TRANSISTOR, SI, NPN	218396	04713	2N3904	1		
R1	RES, DEP. CAR, 220 +/-5%, 1/4W	342626	80031	CR251-4-5P 220ET	1		
R2	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	9		
R3	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47KT	2		
R4	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P 4K7T	1		
R5	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
R6	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1KT	2		
R7	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P 4K7T	1		
R8	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
R9	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
R10	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
R11	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
R12	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
R13	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
R14	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	2		
R15	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P 470ET	1		
R17	RES, DEP. CAR, 10K +/-5%, 1/4W	343426	80031	CR251-4-5P1KT	2		

Table 608A-3. Isolator PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R18	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	1		
R20	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R21	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47KT	2		
R24	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10KT	REF		
T1	INDUCTOR	437608	89536	437608	4		
T2	INDUCTOR	437590	89536	437590	4		
T3	INDUCTOR	437608	89536	437608	REF		
T4	INDUCTOR	437590	89536	437590	REF		
T5	INDUCTOR	437590	89536	437590	REF		
T6	INDUCTOR	437608	89536	437608	REF		
T7	INDUCTOR	437590	89536	437590	REF		
T8	INDUCTOR	437608	89536	437608	REF		
U1	⊗IC, C-MOS, HEX BUFFER/INVERTER	381830	02735	CD4050AE	3	1	
U2	⊗IC, C-MOS, HEX BUFFER/INVERTER	381830	02735	CD4050AE	REF		
U3	IC, TTL, MSI 8 BIT SHIFT REGISTER	293118	01295	SN74165N	2	1	
U4	IC, TTL, QUAD, 2INPUT HV INTRF NAND	408021	18324	N7426A	2	1	
U5	⊗IC, C-MOS, HEX BUFFER/INVERTER	381830	02735	CD4050AE	REF		
U6	IC, TTL, POS NAND GATES, HEX INVERTERS	393058	01295	SN74LS04N	2	1	
U7	IC, TTL, MSI 8-BIT SHIFT REGISTER	293118	01295	SN74165N	REF		
U8	IC, TTL, LO PWR, SNGL/DUAL RETRIG	404186	01295	SN74LS123N	3	1	
U9	IC, TTL, QUAD 2-INPUT NAND GATE	363580	01295	SN7400SN	1		
U10	IC, POS NAND GATES, TRIPLE 3 INPUT	393074	01295	SN74LS10N	1	1	
U11	IC, POS NOR GATES, TOTEM POLE OUTPUTS	393041	01295	SN74LS02N	2	1	
U12	⊗IC, COS/MOS, QUAD 2-INPUT NOR GATES	355172	02735	CD4001AE	1		
U13	⊗IC, C-MOS, TRI-STATE HEX NONINV BUFFERS	407759	12040	MM80C97N	2	1	
U14	IC, TTL, LO PWR, SNGL/DUAL RETRIG	404186	01295	SN74LS123N	REF		
U15	IC, TTL, QUAD, 2INPUT HV INTRF NAND	408021	18324	N7426A	REF		
U16	IC, SHIFT REGISTER, 8 BIT PARALLEL OUT	272138	01295	SN74164N	2	1	
U17	RES NETWORK, 10K +/-5%, 1/4W	355305	89536	355305	1	1	
U18	⊗IC, C-MOS, QUAD 2-INPUT AND GATES	408401	02735	CD4081B1	1	1	
U19	IC, POS NOR GATES, TOTEM POLE OUTPUTS	393041	01295	SN74LS02N	REF		
U20	IC, SHIFT REGISTER, 8 BIT PARALLEL OUT	272138	01295	SN74164N	REF		
U21	⊗IC, C-MOS, TRI-STATE HEX NONINV BUFFERS	407759	12040	MM80C97N	REF		
U22	⊗IC, COS/MOS, QUAD 2-INPUT NOR GATES	355172	02735	CD4001AE	REF		
U23	IC, TTL, LO PWR, SNGL/DUAL RETRIG	404186	01295	SN74LS123N	REF		
U24	IC, TTL, POS NAND GATES, HEX INVERTERS	393058	01295	SN74LS04N	REF		
U25	⊗IC, C-MOS, TRIPLE 3-INPUT NOR GATES	355180	02735	CD4025AE	1	1	
U26	⊗IC, COS/MOS, QUAD 2-INPUT NOR GATES	355172	02735	CD4001AE	1		
U31	⊗IC, C-MOS, DUAL "D" FLIP FLOP	340117	04713	MC14013CP	1		
U32	⊗IC, C-MOS, FAST QUAD 2-INPUT NAND GATE	413211	12040	34011PC/4011PC	1		
U33	⊗IC, C-MOS, TRIPLE 3-INPUT NAND GAE	375147	04713	MC14023CP	1		
U35	⊗IC, C-MOS, HEX SCHMITT TRIGGER	477810	12040	MM74C914N	1		

▷1 SEE TABLE 5-17 AT THE END

OF SECTION 5.


U3
U7
U11
U4
C6
RED
GRN
RED
GRN
T1
R12
U14
U10
U9
C1
R1
C8
R13
C9
R5
RED
GRN
RED
GRN
T3
R21
C2
R2
R4
R11
R7
U13
U12
R24
U8
Q2
T5
U2
U6
U31
U32
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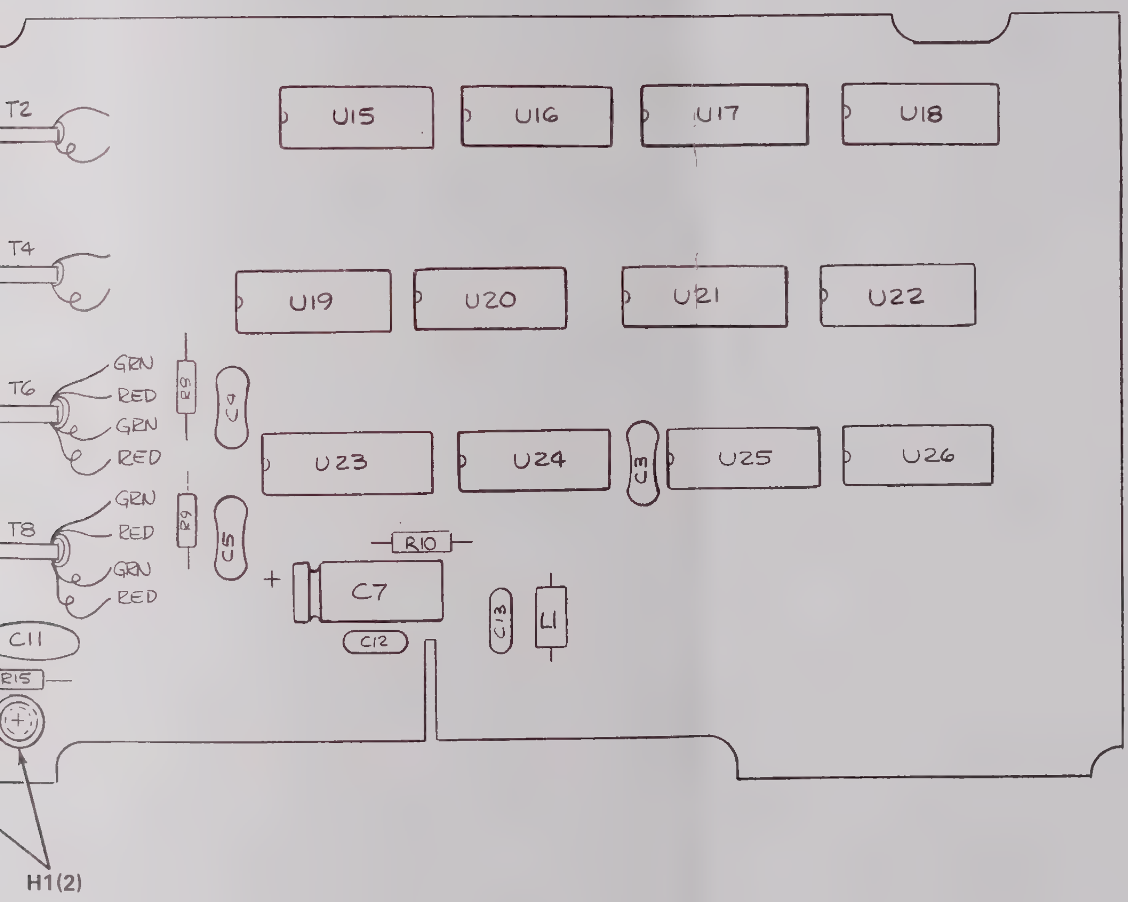
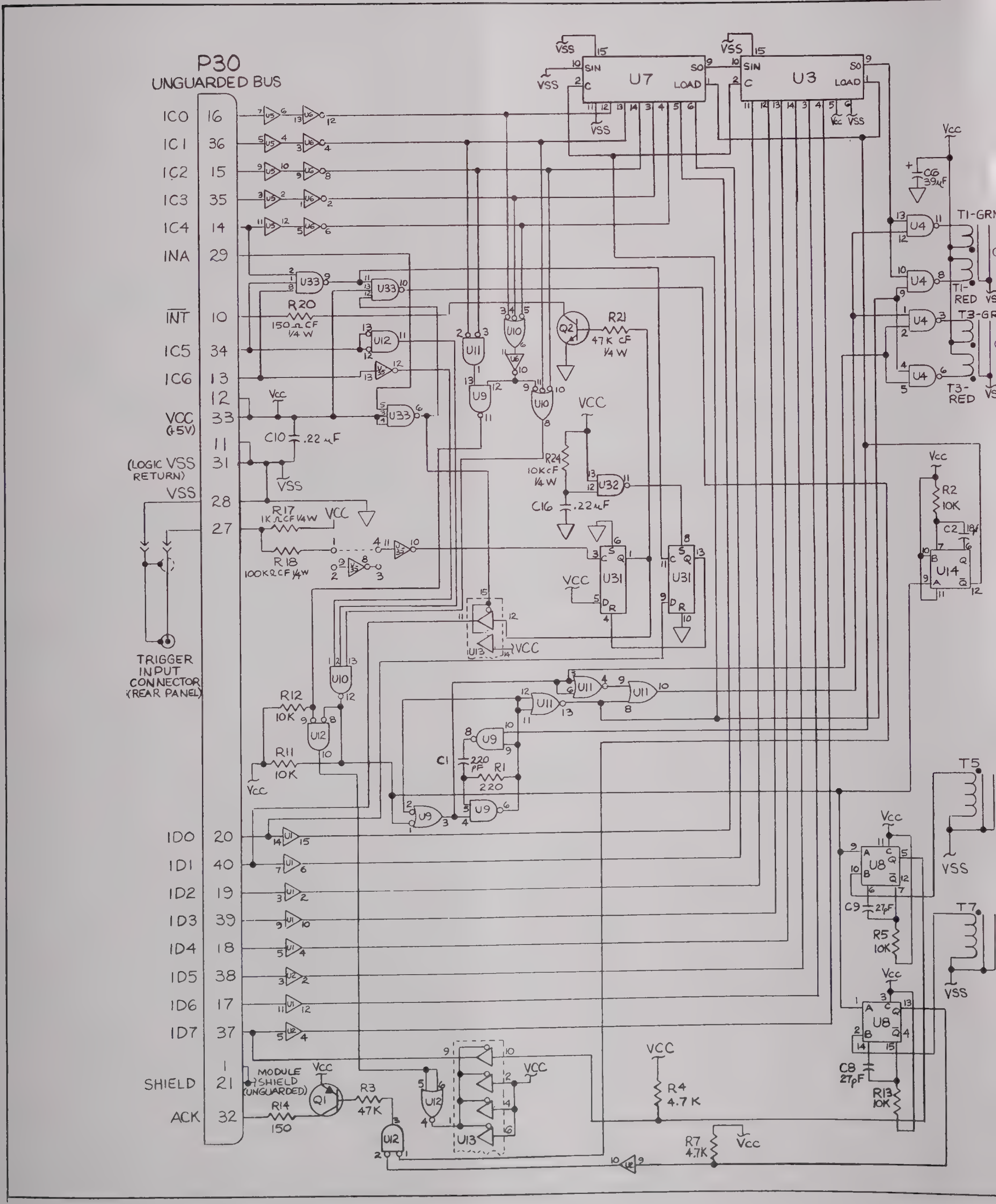
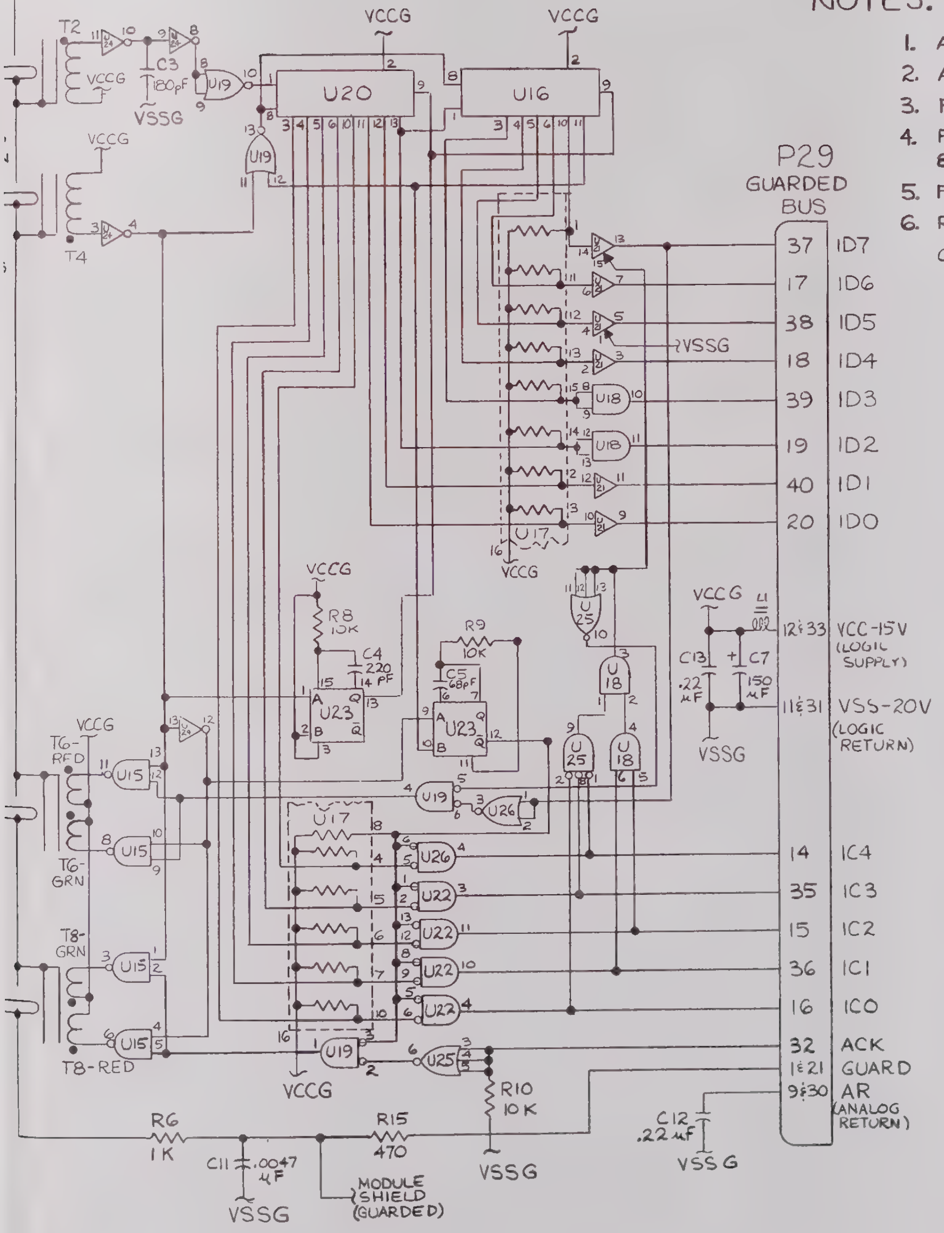
R18
C10
R20
U1
R6


T2
T4
T6
T8
GRN
RED
GRN
RED
GRN
RED
GRN
RED
U15
U16
U17
U18
U19
U20
U21
U22
U23
U24
U25
U26
R8
R9
R10
R15
C3
C4
C5
C7
C11
C12
C13
L1
+
H1(2)

8502A-1781

Figure 608A-3. Isolator PCB Assembly


P30
UNGUARDED BUS
IC0 16
IC1 36
IC2 15
IC3 35
IC4 14
INA 29
INT 10
IC5 34
IC6 13
12
VCC (+5V) 33
11
(LOGIC VSS RETURN) 31
VSS 28
27
ID0 20
ID1 40
ID2 19
ID3 39
ID4 18
ID5 38
ID6 17
ID7 37
1
SHIELD 21
ACK 32
U7
U3
SIN
SO
C
LOAD
VSS
Vcc
U5
U6
U33
U12
U11
U10
U9
U31
U32
U13
U1
U2
U8
U4
U14
Q1
Q2
R20 150Ω CF 1/4 W
R21 47K CF 1/4 W
R24 10K CF 1/4 W
C16 .22 μF
C10 .22 μF
R17 1K Ω CF 1/4 W
R18 100K Ω CF 1/4 W
R12 10K
R11 10K
C1 220 pF
R1 220
R14 150
R3 47K
R4 4.7 K
R7 4.7K
C6 39μF
R2 10K
C2 18
C9 27pF
R5 10K
C8 27pF
R13 10K
VCC
TRIGGER INPUT CONNECTOR (REAR PANEL)
MODULE SHIELD (UNGUARDED)
T1-GRN
T1-RED
T3-GR
T3-RED
T5
T7
VSS


T2
VCCG
C3
180pF
VSSG
U19
U20
U16
VCCG
VCCG
T4
P29
GUARDED BUS
37 ID7
17 ID6
38 ID5
18 ID4
39 ID3
19 ID2
40 ID1
20 ID0
VSSG
U21
U18
U17
VCCG
R8
10K
C4
220 pF
U23
R9
10K
C5
68pF
U25
VCCG
C13
.22 µF
C7
150 µF
12&33 VCC-15V
(LOGIC SUPPLY)
11&31 VSS-20V
(LOGIC RETURN)
VSSG
T6-RED
T6-GRN
T8-GRN
T8-RED
U15
U26
U22
14 IC4
35 IC3
15 IC2
36 IC1
16 IC0
32 ACK
1&21 GUARD
9&30 AR
(ANALOG RETURN)
R10
10K
C12
.22 µF
VSSG
R6
1K
R15
470
C11
.0047 µF
VSSG
MODULE SHIELD (GUARDED)
VSSG

NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.C. 1/4 W 5%.
3. FOR ASSY DRAWING SEE 8502A-4181
4. FOR REF. DES. DRAWING SEE 8502A-1681.
5. FOR P.C.B. SEE 8502A-3081
6. REF. DES. NO'S. LAST USED: C16, R24, U33, Q2, T8

UNGUARDED BUS SIDE		
I.C. NO	VCC	VSS
U32	1,2,5,6,8, 9, 14	7
U1	1	8
U2	1, 11, 14	7, 8
U3, U7, U8, U13, U14	16	8
U4, U6, U9, U10, U11, U12, U31, U33	14	7
U5	1, 14	8
U35	1,3,5,14	7

GUARDED BUS SIDE		
I.C. NO.	VCC	VSS
U15, U16, U19, U20, U22, U24, U25, U18	14	7
U21, U23	16	8
U26	8, 9, 12, 13, 14	7

8502A-1181

Figure 608A-3. Isolator PCB Assembly (cont)

Option —09A
AC/DC Converter (RMS)

609A-1. INTRODUCTION

609A-2. The AC/DC Converter (RMS) is used to provide accurate ac or ac + dc measurements without error due to waveform distortion. Measurements up to 1000 Vac in four ranges with a bandwidth of 10 Hz to 300 kHz may be made (input volt-hertz product not to exceed 2×10^7). Input impedance is 1 MΩ shunted by less than 100 pf.

609A-3. SPECIFICATIONS

609A-4. Table 609-1 lists the specifications for the true RMS Converter.

609A-5. INSTALLATION

609A-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing the AC/DC Converter (RMS) module. The interconnect diagram in Section 8 contains a table listing permissable and preferred slots.

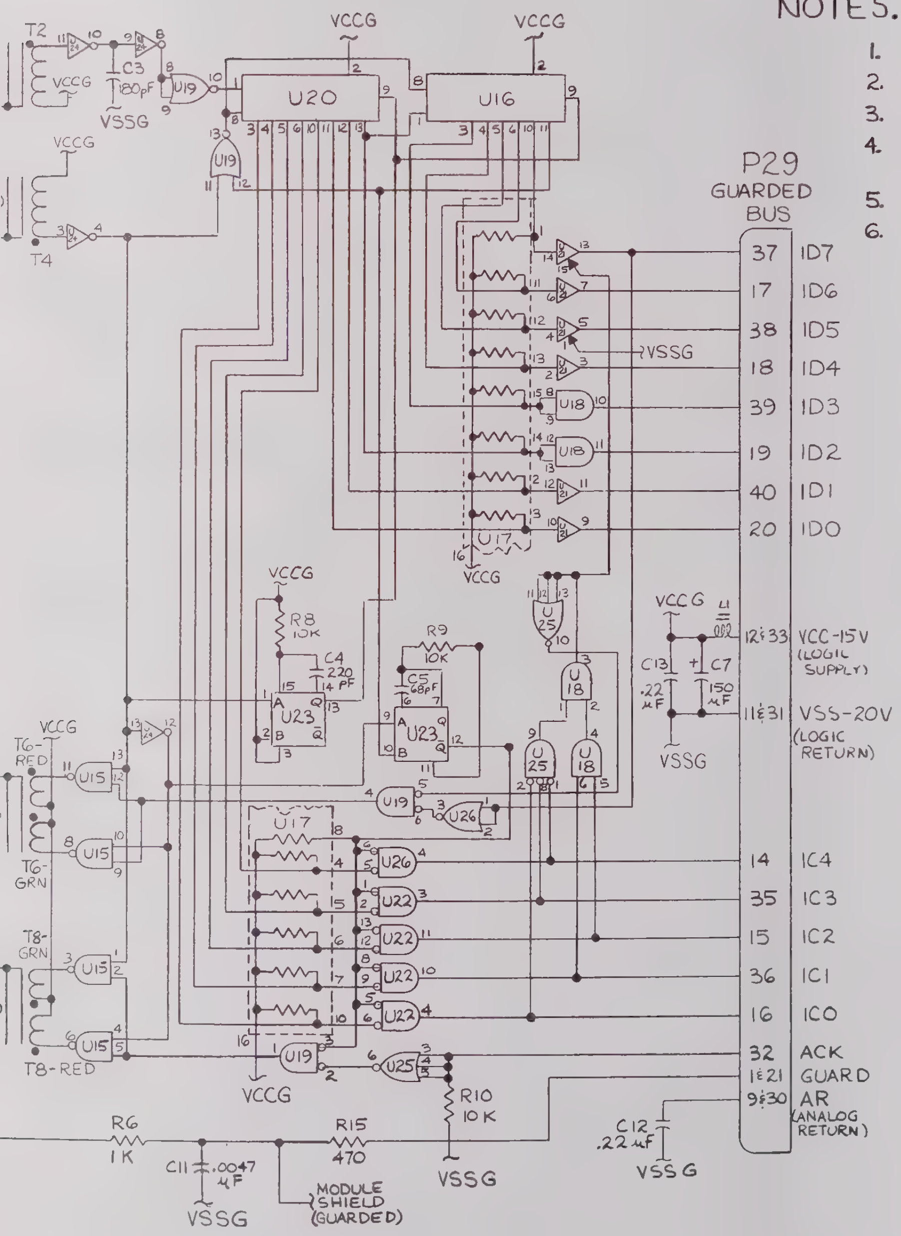
609A-7. OPERATING NOTES

609A-8. Operation of the front panel controls is the same as described in Section 2. An ac voltage on a dc level may be measured by depressing both the Vdc and the Vac function switches at the same time. The reading displayed will be the rms value of the two voltages combined. External reference inputs at the rear panel must be dc voltages only. The slow filter (FILTER LED illuminated) must be selected for full accuracy below 400 Hz.

609A-9. THEORY OF OPERATION

609A-10. The function of the RMS Converter is to accept signals from either the input terminals or the optional Current Shunts module and to convert the input signal to a dc level proportional to the rms value of the input. The dc output from the RMS Converter is routed on the Guarded Bus to the Active Filter module and then to the A/D Converter. True rms conversion is mathematically obtained by averaging the squared value of the input, then taking the square root ($V_{rms} = \sqrt{\overline{Vin^2}}$). Limitations to the realization of this mathematical formula using operational techniques are crest factor (ratio of peak value to rms value, limited by the dynamic range of the amplifiers), frequency response, and accuracy.

609A-11. Input signals are applied to the Range Amplifier (Q1, U3) to be brought within the 1V rms range. Refer to Figure 609A-1. Before a signal can be operationally squared, it must be converted to an absolute value. Balance Amplifier (U4, Q10) performs this function by inverting and rectifying the signal from U3. Outputs from the Range Amplifier and the Balance Amplifier are applied through R33 and R31 to the summing node of the Squaring Amplifier (U5, Q11). Due to the ratio of R33 to R31, the inverted negative half-cycles from the Balance Amplifier are twice the amplitude of the negative half-cycles from the Range Amplifier. When summed, the waveform is the absolute value of the output from the Range Amplifier. The conversion to rms is performed by the Squaring Amplifier, Integrator, and Square Root Amplifier. Implementation of these functions depends on the logarithmic response of PN junctions. Since two PN junctions are used in each of two parts of a feedback loop, a double logarithmic response is generated ($2 \log X = \log X^2$). The Squaring Amplifier converts the signal to a current flowing through the emitters of two transistors, Q8A and Q12A. These two transistors are configured with two additional transistors, Q12B and Q8B, in a feedback loop which constrains the output voltage to be the square root of the integral of the square of the current flowing in Q8A and Q12A.


T2
VCCG
C3
180pF
U19
VSSG
U20
U16
VCCG
T4
P29
GUARDED
BUS
37 ID7
17 ID6
38 ID5
18 ID4
39 ID3
19 ID2
40 ID1
20 ID0
VSSG
U18
U21
U17
VCCG
R8
10K
C4
220
PF
U23
R9
10K
C5
68pF
U25
U26
U15
T6-RED
T6-GRN
T8-GRN
T8-RED
U24
U22
C13
.22 µF
C7
150 µF
L1
.002
12&33 VCC-15V (LOGIC SUPPLY)
11&31 VSS-20V (LOGIC RETURN)
14 IC4
35 IC3
15 IC2
36 IC1
16 IC0
32 ACK
1&21 GUARD
9&30 AR (ANALOG RETURN)
R10
10 K
C12
.22 µF
R6
1K
C11
.0047 µF
R15
470
MODULE SHIELD (GUARDED)

NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.C. 1/4 W 5%.
3. FOR ASSY DRAWING SEE 8502A-4181
4. FOR REF. DES. DRAWING SEE 8502A-1681.
5. FOR P.C.B. SEE 8502A-3081
6. REF. DES. NO'S. LAST USED: C16, R24, U33, Q2, T8

UNGUARDED BUS SIDE

I.C. NO	VCC	VSS
U32	1,2,5,6,8,9,14	7
U1	1	8
U2	1,11,14	7,8
U3,U7,U8,U13,U14	16	8
U4,U6,U9,U10,U11,U12,U31,U33	14	7
U5	1, 14	8
U35	1,3,5,14	7

GUARDED BUS SIDE

I.C. NO.	VCC	VSS
U15,U16,U19,U20,U22,U24,U25,U18	14	7
U21,U23	16	8
U26	8,9,12,13, 14	7

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Figure 608A-3. Isolator PCB Assembly (cont)

Option —09A
AC/DC Converter (RMS)

609A-1. INTRODUCTION

609A-2. The AC/DC Converter (RMS) is used to provide accurate ac or ac + dc measurements without error due to waveform distortion. Measurements up to 1000 Vac in four ranges with a bandwidth of 10 Hz to 300 kHz may be made (input volt-hertz product not to exceed 2×10^7). Input impedance is 1 MΩ shunted by less than 100 pf.

609A-3. SPECIFICATIONS

609A-4. Table 609-1 lists the specifications for the true RMS Converter.

609A-5. INSTALLATION

609A-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing the AC/DC Converter (RMS) module. The interconnect diagram in Section 8 contains a table listing permissable and preferred slots.

609A-7. OPERATING NOTES

609A-8. Operation of the front panel controls is the same as described in Section 2. An ac voltage on a dc level may be measured by depressing both the Vdc and the Vac function switches at the same time. The reading displayed will be the rms value of the two voltages combined. External reference inputs at the rear panel must be dc voltages only. The slow filter (FILTER LED illuminated) must be selected for full accuracy below 400 Hz.

609A-9. THEORY OF OPERATION

609A-10. The function of the RMS Converter is to accept signals from either the input terminals or the optional Current Shunts module and to convert the input signal to a dc level proportional to the rms value of the input. The dc output from the RMS Converter is routed on the Guarded Bus to the Active Filter module and then to the A/D Converter. True rms conversion is mathematically obtained by averaging the squared value of the input, then taking the square root ($V_{rms} = \sqrt{\overline{V_{in}^2}}$). Limitations to the realization of this mathematical formula using operational techniques are crest factor (ratio of peak value to rms value, limited by the dynamic range of the amplifiers), frequency response, and accuracy.

609A-11. Input signals are applied to the Range Amplifier (Q1, U3) to be brought within the 1V rms range. Refer to Figure 609A-1. Before a signal can be operationally squared, it must be converted to an absolute value. Balance Amplifier (U4, Q10) performs this function by inverting and rectifying the signal from U3. Outputs from the Range Amplifier and the Balance Amplifier are applied through R33 and R31 to the summing node of the Squaring Amplifier (U5, Q11). Due to the ratio of R33 to R31, the inverted negative half-cycles from the Balance Amplifier are twice the amplitude of the negative half-cycles from the Range Amplifier. When summed, the waveform is the absolute value of the output from the Range Amplifier. The conversion to rms is performed by the Squaring Amplifier, Integrator, and Square Root Amplifier. Implementation of these functions depends on the logarithmic response of PN junctions. Since two PN junctions are used in each of two parts of a feedback loop, a double logarithmic response is generated ($2 \log X = \log X^2$). The Squaring Amplifier converts the signal to a current flowing through the emitters of two transistors, Q8A and Q12A. These two transistors are configured with two additional transistors, Q12B and Q8B, in a feedback loop which constrains the output voltage to be the square root of the integral of the square of the current flowing in Q8A and Q12A.

Table 609A-1. AC/DC Converter (RMS) Specifications

ACCURACY

(Refer to Section 1 for required environmental conditions)

Accuracy (0.1% of Range to Full Scale)

Frequency	24 Hours			90 Days			1 Year		
	% of Input	+% FS AC	+% FS AC + DC	% of Input	+% FS AC	+% FS AC + DC	% of Input	+% FS AC	+% FS AC + DC
DC	0.075	–	0.03	0.1	–	0.03	0.2	–	0.06
10 Hz to 20 Hz	0.75	0.04	0.06	1.0	0.04	0.06	2.0	0.08	0.12
20 Hz to 50 Hz	0.35	0.012	0.03	0.5	0.012	0.03	1.0	0.04	0.06
50 Hz to 10 kHz	0.075	0.012	0.03	0.1	0.012	0.03	0.2	0.04	0.06
10 kHz to 30 kHz	0.15	0.04	0.06	0.2	0.04	0.06	0.4	0.08	0.12
30 kHz to 50 kHz	0.2	0.1	0.12	0.3	0.1	0.12	0.6	0.6	0.25
50 kHz to 100 kHz	0.75	0.3	0.3	1.0	0.3	0.3	2.0	0.6	0.6
100 kHz to 300 kHz	1.5	0.5	0.5	2.0	0.5	0.5	2.8	1.0	1.0
300 kHz to 1 MHz	2.9	1.3	1.3	3.3	1.8	1.8	3.7	2.1	2.1

NOTES:

1. *Slow Filter must be used for full accuracy below 400 Hz.*
2. *Volt-Hertz product not to exceed 2×10^7 for 100V and 1000V ranges and 1×10^7 for for 1V and 10V ranges.*
3. *For inputs above 500V, multiply accuracy by:* $\left(\frac{2000V + V_{in}}{2000V}\right)$

INSTRUMENT OPERATING CHARACTERISTICS

INPUT CHARACTERISTICS

Range	Full Scale	Resolution		Impedance
		Normal	High	
1V	2.5V	10 uV	1 uV	1 MΩ, <100 pF
10V	20V	100 uV	10 uV	
100V	160V	1 mV	100 uV	
1000V	1000V	10 mV	1 mV	

MAXIMUM INPUT

1000V rms or 2×10^7 volt-hertz product, whichever is less.

SETTLING TIME (To within 0.1%)

100 ms, Fast Filter
500 ms, Slow Filter

COMMON MODE REJECTION

(100Ω Unbalance)

120 dB, dc to 60 Hz

CREST FACTOR

>7 at full scale, increasing down scale by:

$$7 \times \sqrt{\frac{V_{Range}}{V_{Input}}}$$

(1400 V peak max)
1000 V range

TEMPERATURE COEFFICIENT

(0°C to 18°C and 28°C to 50°C)

AC* Only	±(40 ppm or Reading + 20 ppm f.s.)/°C
AC* + DC	±(40 ppm of Reading + 40 ppm f.s.)/°C

**Frequencies <10 kHz*

DIGITIZING

Same as dc volts

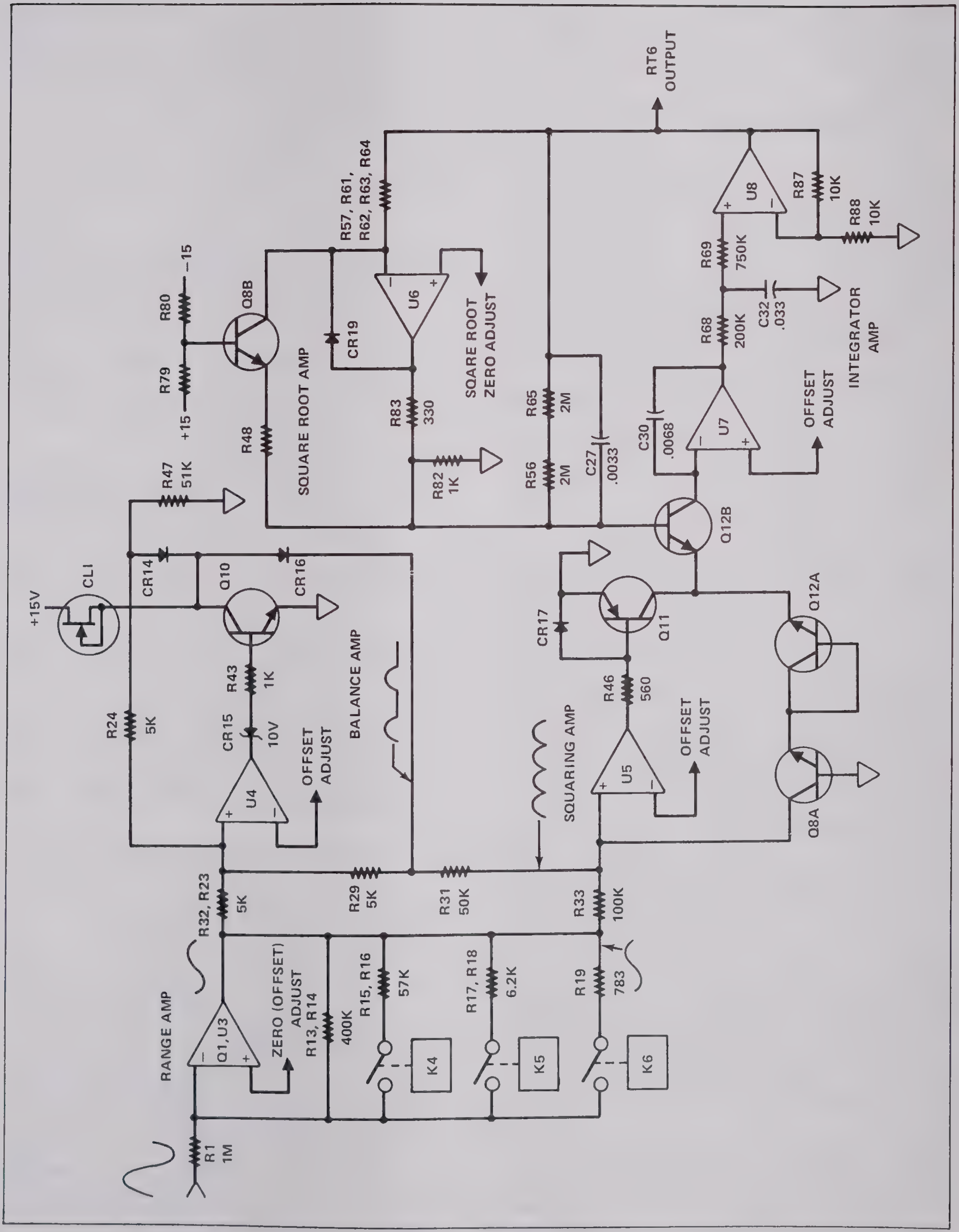

RT6
OUTPUT
R57, R61,
R62, R63, R64
R80
–15
Q8B
+15
R79
R48
SQUARE ROOT AMP
CR19
U6
SQARE ROOT
ZERO ADJUST
R83
330
R82
1K
R65
2M
R56
2M
C27
.0033
C30
.0068
U7
OFFSET
ADJUST
R68
200K
C32
.033
INTEGRATOR
AMP
R69
750K
U8
R87
10K
R88
10K
+15V
CLI
R47
51K
CR14
Q10
CR16
R24
5K
R43
1K
CR15
10V
U4
OFFSET
ADJUST
BALANCE AMP
CR17
Q11
Q12B
Q12A
R46
560
U5
OFFSET
ADJUST
SQUARING AMP
Q8A
R32, R23
5K
R29
5K
R31
50K
R33
100K
RANGE AMP
Q1, U3
ZERO (OFFSET)
ADJUST
R13, R14
400K
R15, R16
57K
R17, R18
6.2K
R19
783
K4
K5
K6
R1
1M

Figure 609A-1. AC/DC Converter (RMS)

609A-12. Circuit Description

609A-13. Refer to the schematic for the following discussion.

609A-14. RANGE AMPLIFIER

609A-15. The Range Amplifier is an inverting amplifier with gain control provided by switching feedback impedances. Feedback impedances are controlled by relays K4, K5, or K6, and consist of parallel resistors and capacitors adjusted for proper gain and frequency response. Relays K1, K2, and K7 control the input to the amplifier. K1 is energized for inputs from the input terminals. K7 is energized for inputs from the Current Shunts module. K2 is energized when selecting ac + dc measurements. Gain of the amplifier is set for a 1V rms output with a full-scale sine wave input with the exception of the 1000V range in which the full-scale output is .8V rms. Q1 and U3 provide the forward gain of the amplifier. CR6, CR7, CR21, and CR22 provide input protection. Q2 drives the guard for the summing node of the operational amplifier.

609A-16. BALANCE AMPLIFIER

609A-17. The Balance Amplifier is an inverting, unity-gain amplifier with diodes in the feedback paths to provide rectification. CL1 and Q10 are configured as a current source driven by U4. A high impedance current source is used to minimize the effects of the diodes on the gain of the amplifier. Due to the unity gain of the inverting amplifier and the ratio of R33 to R31, the negative half-cycles from the Range Amplifier are summed with positive half-cycles having twice the amplitude from the Balance Amplifier. The result is the absolute value of the output from the Range Amplifier. Q6 is used to extend the frequency response of the amplifier.

609A-18. COMPUTATION

609A-19. The Squaring Amplifier, Square Root Amplifier, and Integrator Amplifier work together to perform the rms conversion. This is accomplished by regulating the current in four transistors, Q8A, Q12A, Q8B, and Q12B, matched for temperature coefficient and response characteristics. The Squaring Amplifier sums the outputs from the Range Amplifier and the Balance Amplifier such that the current flowing through its feedback path (Q8A, Q12A) is proportional to the absolute value of the input signal. Forward gain of the amplifier is provided by U5 and Q11 with Q7 extending the frequency response.

609A-20. Q12B is configured such that the integral of its collector current is the output voltage. U7 and U8 integrate the collector current of Q12B. Q8B is configured such that its collector current is proportional to the output voltage. The current through Q8B controls the gain of U6, the Square Root Amplifier, which in turn partially controls the current flowing in Q12B. The integrating time constant of U7 and U8 is determined by R56 and R65 in parallel with C27 or C27 plus C28, depending on which filter is selected from the front panel. The proportionality constant of the converter is such that a full-scale input produces a 20V output on RT6.

609A-21. MAINTENANCE

609A-22. Performance Test

609A-23. Use the following procedure as a performance determination for the AC/DC Converter (RMS). The DC Volts Performance Test given in Section 4 should be done first to ensure proper DC accuracy.

1. Select AC Volts and Autoranging.
2. Connect the AC Calibrator output to the instrument input terminals.
3. Sequentially apply the input voltages and frequencies listed in Table 609A-2, verifying that the instrument reading is within the listed tolerance.
4. Disconnect the AC Calibrator and connect the DC Calibrator.
5. Simultaneously select DC Volts and AC Volts (both indicators illuminated).
6. Select an output from the DC Calibrator of +10.0000 Vdc.
7. The instrument display should be within 9.9840 and 10.0160.
8. Reverse the leads at the output of the DC Calibrator. The display should still read within the limits of Step 8.

Table 609A-2. Performance Test

INPUT		8500A READING	
FREQ	VOLTAGE	LOW	HIGH
10 kHz	1 V	0.99870	1.00130
50 kHz	1 V	0.99450	1.00550
10 kHz	10 V	9.9876	10.0124
50 kHz	10 V	9.9500	10.0500
10 kHz	100 V	99.881	100.119
50 kHz	100 V	99.540	100.460
10 kHz	1000 V	998.48	1001.52

609A-24. Calibration

609A-25. Before calibrating the RMS Converter, perform the DC Calibration procedure in Section 4. Remove the Calibration Memory if installed and allow a two hour warm-up. Allow adequate warm-up time for the Calibrator used, as specified in the Calibrator manual. After calibration is complete, reinstall the Calibration Memory and enter new values at the cardinal points of each range (zero may be entered).

609A-26. Use the following procedure to calibrate the AC/DC Converter (RMS). All adjustments given are on the RMS Converter and are accessible at the top of the module. R66, R55, C24 and R38 are adjustments not accessible from the top of the module which should not require adjustment unless parts have been replaced. Adjustment procedures for these adjustments are given in Troubleshooting in this section of the manual.

609A-27. Range Zero Adjustment is accomplished using the following steps:

1. Select the 10V range.
2. Simultaneously select DC Volts and AC Volts (both indicators illuminated).
3. Connect the test DVM HI to TP5, LO to TP1.
4. Short the input terminals.
5. Adjust R12, RANGE ZERO, for a reading on the test DVM of 0 ± 30 μV.
6. Remove the input short and the test DVM.

609A-28. Balance Zero Adjustment is accomplished using the following steps:

1. Apply -0.2000000 to the input terminals from the DC Calibrator. Record the reading.
2. Reverse the polarity of the input.
3. Adjust R42, BALANCE ZERO, twice as far as required to reach the reading noted.
4. Reverse polarity again. Readjust R42 until the readings are within 10 μV for either polarity without further adjustment.

609A-29. Balance Gain Adjustment is accomplished using the following steps:

1. Select the Cal mode (CAL switch down, CAL indicator illuminated). Ignore the cal digit for the remainder of this procedure.

> *NOTE*
>
> *Entering the cal mode allows over-range inputs without the over-range indication flashing.*

2. Apply -20.00000 Vdc to the input from the DC Calibrator. Note the reading.
3. Reverse the polarity.
4. Adjust R32, BALANCE GAIN, to the reading noted.
5. Reverse the polarity again. Readjust R32 until the readings with both polarities are within 10 digits without further adjustment.

609A-30. AC Zero Adjustment is accomplished using the following steps:

1. Select AC Volts, 1V range.
2. Connect the AC Calibrator to the input terminal.
3. Apply 2.5 mV AC, 500 Hz to the input.
4. Adjust R45, AC ZERO, for a reading between 0.00245 and 0.00255.

609A-31. Calibration Adjustments

609A-32. Sequentially apply the input voltages and frequencies listed in Table 609A-3, performing the adjustments as necessary to bring the reading within the stated tolerance. Select AC Volts and manual ranging for these adjustments. If in the first step R64 does not have the required range, perform the coarse calibration in the troubleshooting section. Steps 9 and 24 require a 50Ω termination at the instrument input terminals and the use of four-wire sensing with the AC Calibrator. Two test cables, each with twisted wires, may be used.

609A-33. Troubleshooting

609A-34. Troubleshooting procedures for the AC/DC Converter (RMS) follow the format used in Section 4. Table 609A-4 assures that the problem actually is in the RMS Converter. Figure 609A-2 gives a sympton analysis approach to troubleshooting, with possible failures listed in order of probability, and gives the address and data field used to set up the module. DO NOT remove or install modules with the power on.

609A-35. If Q8 or Q12 are replaced, the module must be returned to the factory (attn: PARTS) for temperature compensation. This is also the only time R38, CREST FACTOR ADJUST, should require readjustment. Do not attempt to adjust R38 as no crest factor generators are commercially available.

Table 609A-3. Calibration Adjustment

STEP	RANGE	INPUT		ADJUST/ CHECK	TOLERANCE	
		VOLTAGE	FREQUENCY		LOW	HIGH
1	1000V	500V[1]	500 Hz	R64	499.90	500.10
2	1000V	500V[1]	50 kHz	C4	499.80	500.20
3	1000V	1000V[1]	10 kHz	Wait 30 sec. Check	999.20	1000.80
4	1V	2.5V	500 Hz	R14	2.49975	2.50025
5	1V	2.5V	50 kHz	C9	2.49900	2.50100
6	10V	20V	500 Hz	R16	19.9980	20.0020
7	10V	20V	50 kHz	C11	19.9900	20.0100
8	10V	10V	1 MHz	Check (R75)[2]	9.8000	10.2000
9	1V	1V	1 MHz[3]	Check (R75)[2]	0.9800	1.02000
10	1V	2.5V	300 kHz	Check	2.48000	2.52000
11	1V	2.5V	20 kHz	Check	2.49900	2.50100
12	1V	2.5V	50 Hz[4]	Check	2.49900	2.50100
13	1V	2.5V	100 kHz	Check	2.49000	2.51000
14	1V	.25V	100 kHz	Check	0.24600	0.25400
15	1V	2.5 mV	50 kHz	Check	0.00150	0.00350
16	1V	2.5 mV	500 Hz	Check	0.00230	0.00270
17	1V	.8V	500 Hz	Check	0.79960	0.80040
18	100V	160V[1]	500 Hz	R18	159.960	160.020
19	100V	160V[1]	50 kHz	C14	159.960	160.040
20	100V	67V	300 kHz	Check	66.800	68.200
21	10V	20V	300 kHz	Check	19.7500	20.2500
22	1V	.8V	300 kHz	Check	0.78500	0.81500
23	1V	.2V	300 kHz	Check	0.18800	0.21200
24	1V	.1V	1 MHz[3]	Check	0.07000	0.13000

1. Use CAUTION, Dangerous voltage.
2. If R75 is adjusted, repeat the previous steps.
3. Terminate cable in 50Ω; use four-wire sense on Calibrator as explained in the text.
4. FILTER must be ON.

Table 609-4. AC Converter Isolation

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Do the DC Performance Test (Section4).		
2	Is DC Volts within tolerance?	3	Section 4
3	Is the Calibration Memory module installed?	4	6
4	Remove the Calibration Memory module. Is AC OK?	5	6
5	Bad Calibration Memory. Go to Section 604.		
6	Is Isolator installed?	7	10
7	Replace Isolator with Bus Interconnect/Monitor pcb.		
8	Is AC OK?	9	10
9	Bad Isolator. Go to Section 608.		
10	Remove DC Signal Conditioner. Is AC OK?	11	12
11	DC Signal Conditioner interfering with AC. The problem in the DC Signal Conditioner is one of the following: 1. Digital Logic Bad, 2. K1 or K2 shorted, 3. Q6, Q7, Q8 Bad.		
12	Install Bus Interconnect/Monitor if not already installed.		
13	Check power supply voltages as follows: VA1 = +14.24 to 15.75V VA4 = –29 to –32V VA2 = –14.25 to –15.75V Vcc = –15V Difference =4.9 VA3 = +29 to 32V Vss = –20V to 5.2		
14	Are the supply voltages OK?	15	Section 4
15	Go to Figure 609-2.		

SYMPTOM	POSSIBLE FAILURE
High reading on display with open inputs, 1000V range	C24 misadjusted, Q9, Q10, U4
High frequency (300 kHz) bad	C24 misadjusted or bad, U3
Reading not stable	U3, U4
Crest factor bad	Q8, Q12
AC breaks down (overload source above 500V)	K7
AC out of tolerance in slow filter mode	Q13 and Q14, Q16 and Q17
One range bad	Digital Logic Range Relays, CR14, CR16
All ranges bad	U3, Q1, U5, Q7, U7, U8, K8, K1
Excessive noise	U3, Q2
Display blanks	U1, U10

The largest single failure items tend to be relays and electrolytic capacitors

Note: If Q8 or Q12 is replaced, the module should be returned to the factory (Attn. Parts) for temperature compensation and adjustment of R38.

Address IC 0, 2, 4 high

IDO =0, ID1 = 0 –DC Coupled AC
IDO = 1, ID1 =0 –AC Volts
DIO = 0, ID1 = 1 –RT1 input for AC Current
ID2 =0 –Filter On
ID3 =0 –10V range
ID4 =0 –100V range
ID5 =0 –1000V range
ID3 through ID5 = 1–1V range

Figure 609-2. Symptom Analysis

609A-36. Preliminary Calibration

609A-37. If other parts are replaced, it may be necessary to make the following adjustments before continuing with the calibration procedure. To assure proper functioning of the module the following procedure should be completed. Many of the adjustments must be performed again in the final calibration procedure. Always perform final calibration from the beginning of the procedure. Select the cal mode by placing the CAL switch in the down position. Ignore the cal digit for this procedure. Some of these adjustments are not accessible from the top of the module. Center all adjustments before beginning calibration except for R38, C24, and R64. R64 should be set fully counterclockwise. R38 should NOT be changed.

CAUTION

When high voltages are applied to the input terminals and the module is not enclosed in the case, hazardous voltages are present on the board. Use an insulated tool for making adjustments while keeping hands away from the PCB.

1. Select AC Volts and the 1V range (manually) and short the input terminals.
2. Short TP3 and TP4 to the metal divider on the board.
3. Connect the test DVM HI to TP2 and LO to TP1.
4. Adjust R66, INTEGRATOR ZERO, for 0V ±100 μV.
5. Remove the short from TP3.
6. Add a jumper from the bottom of R57 (junction with R61) to a jumper added across R48.
7. Connect the test DVM HI to TP3.
8. Adjust R55, SQUARE ROOT ZERO, for 0V ±100 μV.
9. Remove the short from TP4 and the jumper from R48.
10. Simultaneously select AC Volts and DC Volts; manually select the 10V range.
11. Connect the test DVM HI to TP5.
12. Adjust R12. RANGE ZERO, for 0V ± 30 μV.
13. Disconnect the test DVM and remove the short from the input terminals.
14. Center R45, AC ZERO, and apply -0.2V from the DC Calibrator to the input terminals. Note the reading on the display.
15. Reverse the polarity of the input and adjust R42, BALANCE ZERO, twice as far as required to reach the reading noted.
16. Reverse the polarity again and readjust R42 until the readings obtained with both polarities are within 10 digits without further adjustment.
17. Apply -20V DC to the input and note the reading.
18. Reverse the input polarity and adjust R32, BALANCE GAIN, for the same reading as noted in the last step ±5 digits.
19. Apply -0.02V DC and adjust R45, AC Zero, for a reading of 0.0200 ±5 digits.
20. Disconnect the DC Calibrator and connect the AC Calibrator.
21. Select AC Volts and the 1000V range.
22. Set R64 fully counterclockwise.
23. Apply 500V @ 500 Hz to the input from the AC Calibrator.
24. Note the reading and clip links according to Table 609A-5. Link 1 is across R61, link 2 is across R62, and link 3 is across R63.
25. Adjust R64, 1000V LOW FREQ, ADJUST, for a reading of 500.000V ±20 digits.
26. Change the frequency to 50 kHz and adjust C4, 1000V HIGH FREQ ADJUST, for 500.000V ±20 digits.
27. Apply 2.5V @ 500 Hz to the input and manually select the 1V range.
28. Adjust R14, 1V LF, for 2.50000 ±10 digits.
29. Change the input frequency to 500 kHz and adjust C9, 1V HF-1, for 2.50000 ±100 digits.
30. Change the input frequency to 500 kHz and adjust C24, 1V HF-2, to bring the reading toward 2.5V. Adjusting C24 will require re-adjusting C9. Alternately adjust C9 as in step 29, than C24 @ 500 kHz until a reading of 2.50000V ±3000 digits is obtained.

NOTE
C9 has approximately twice the effect at 500 kHz as at 50 kHz. If C24 hasn't enough range, adjust R75, 1 MHz. Turn it CW to raise the reading or CCW to lower the reading (½ turn is about 3000 digits).

31. Check the stability by selecting the 1000V range and applying 1000V @ 10 kHz. The reading should be 1000.00 ±80 digits. Wait thirty seconds. If the reading is out of tolerance, with caution and an insulated tool, adjust C24 slightly beyond the point where a stable reading is displayed. Recheck steps 29 and 30.

32. Apply 20V @ 500 Hz and select the 10V range.

33. Adjust R16, 10V LF, for a reading of 20.0000 ±20 digits.

34. Change the frequency to 50 kHz and adjust C11, 10V HF, for 20.0000 ±100 digits.

35. Apply 10V @ 1 MHz using four-wire sensing (without the 50Ω termination).

36. Adjust R75, 1 MHz, for a reading of 10.0000 ±100 digits.

37. Apply 1V @ 1 MHz using four-wire sensing with the 50Ω termination at the input terminals. Manually select the 1V range.

38. Initially note the reading without adjusting R75. If this reading is not 1.00000V ±.036V, adjust C24 until the reading is within ±.036V and note this reading. Adjust R75 until the reading is halfway between the noted reading and 1.00000V. This final reading, then, should be 1.00000V ±.018V.

39. Apply 500V @ 50 kHz. The reading should be 500.00 ±20 digits (adjust C4 if necessary).

40. Apply 2.5V @ 500 kHz and check reading for 2.50000 ±.03V. Adjust C24 if necessary to bring the reading within the specification.

41. If C24 was adjusted in Step 40, check the stability by applying 1000V @ 10 kHz. The reading should be stable at 1000.00 ±.8V. Readjust C24 and repeat Step 40 if the reading is unstable.

42. Apply 2.5V @ 50 kHz. Adjust C9 if necessary for a reading of 2.50000 ±.001V.

43. Apply 20V @ 50 kHz and adjust C11 if necessary for a reading of 20.0000 ±.01V.

44. Apply 10V @ 1 MHz using a four-wire cable. The reading should be 10.0000 ±.02V.

45. Apply 1V @ 1 MHz using a four-wire cable with a 50Ω termination. The reading should be 1.00000 ±.02V.

46. If Steps 44 or 45 are out of tolerance repeat Steps 36 through 45.

47. Select the 100V range and apply 160V @ 500 Hz. Verify that R18, 100V LF, will adjust the reading to 160.000V ± 50 digits.

48. Check the output ripple by turning the filter off and applying 2.5V @ 200 Hz from a lab oscillator on the 1V range and adjust the oscillator output for a reading of 2.50000V ± 1000 digits. Connect the oscilloscope HI to TP2, LO to shield. The ripple should be less than 20 mV P-P.

49. Change the frequency to 20 Hz and turn the filter on. Readjust the voltage as in step 44 The ripple should be less than 80 mV P-P.

50. Perform the Calibration procedure (Paragraph 609A-24).

Table 609A-5. High Voltage, Low Frequency Coarse Adjust

Reading	Links Previously Clipped	Clip Links	Replace Links
500 - 495.5 N/A (Pot R64 should adjust properly)		None	None
495.5 - 491.1	1	2	1
	2	1	None
	1 & 2	3	1 & 2
	3	1	None
	1 & 3	2	1
	2 & 3	1	None
500 - 504.5	1	None	1
	2	1	2
	1 & 2	None	1
	3	1 & 2	3
	1 & 3	None	1
	2 & 3	1	3
	1, 2, & 3	None	1

609A-38. PARTS LIST

609A-39. Table 609A-6 gives a parts breakdown for the AC/DC Converter (RMS). Refer to Section 5 for ordering information.

CAUTION
Indicated devices are subject to damage by static discharge.

Table 609A-6. RMS Converter PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-09A	⊛RMS CONVERTER PCB ASSEMBLY FIGURE 609A-3 (MIS-4103T)	ORDER	BY	OPTION -09A			
C1	CAP, MYLAR, 0.22 UF +/-20%, 1200V	268904	84411	JF-65	1		
C2	CAP, PORC, 1.5 PF +/-0.25 PF, 1.7V ACK	461004	95275	VY10CA1R5CA	1		
C3	CAP, MICA, 220 PF +/-5%, 500V	170423	72136	DM15F221J	1		
C4	CAP, VAR, 0.25-1.5 PF, 2000V	218206	72982	530-000	2		
C7	CAP, MYLAR, 0.1 UF +/-10%, 100V	393439	73445	C280MAH/A100K	2		
C8	CAP, PORC, 5.6 PF +/-0.25 PF, 100V	460568	95275	VY10CA5R6CA	1		
C9	CAP, VAR, 0.25-1.5 PF, 2000V	218206	72982	530-000	REF		
C10	CAP, MICA, 43 PF +/-1%, 500V	277202	72136	DM15E430F	1		
C11	CAP, VAR, 0.8-10. PF, 250V	229930	91293	JM2951	1		
C12	CAP, POLY FILM, 0.047 UF +/-10%, 250V	162008	73445	C280MAE/A47K	1		
C13	CAP, MICA, 390 PF +/-1%, 500V	355339	72136	DM15F391F	1		
C14	CAP, VAR, 9-35 PF, 350V	289637	72982	538-006D9-35	1		
C15	CAP, MICA, 3600 PF +/-2%, 500V	176644	72136	DM19F362G	1		
C16	CAP, MICA, 27 PF +/-5%, 500V	177998	72136	DM15F270J	5		
C17	CAP, MICA, 8 PF +/-10%, 500V	216986	72136	DM15C080K	1		
C18	CAP, MICA, 15 PF +/-5%, 500V	148569	72136	DM15C150J	3		
C19	CAP, MICA, 1000 PF +/-5%, 500V	148387	72136	DM19F102J	2		
C20	CAP, MICA, 27 PF +/-5%, 500V	177998	72136	DM15F270J	REF		
C21	CAP, MICA, 2 PF +/-0.5%, 500V	175208	72136	DM15C020E	1		
C22	CAP, MICA, 1000 PF +/-5%, 500V	148387	72136	DM19F102J	REF		
C23	CAP, TA, ELECT, 15 UF +/-10%, 20V	153056	56289	150D156X0020B2	4		
C24	CAP, VAR, 1.7-10 PF, 250V	321109	56289	GKB10000	1		
C25	CAP, MICA, 390 PF +/-5%, 500V	148437	72136	DM15F391J	1		
C26	CAP, MICA, 27 PF +/-5%, 500V	177998	72136	DM15F270J	REF		
C27	CAP, MYLAR, 0.0033 UF +/-10%, 50V	402867	06001	75F1R5A-333	2		
C28	CAP, POLY FILM, 0.01 UF +/-10%, 400V	402818	73445	C280MAF/A10K	1		
C29	CAP, MYLAR, 0.022 UF +/-10%, 250V	234484	73445	C280MAE/A22K	2		
C30	CAP, MYLAR, 0.0068 UF +/-20%, 200V	106070	56289	192P68202	1		
C31	CAP, MICA, 27 PF +/-5%, 500V	177998	72136	DM15F270J	REF		
C32	CAP, MYLAR, 0.033 UF +/-10%, 250V	234492	73445	C280MAE/A33K	2		
C33	CAP, MYLAR, 0.0047 UF +/-10%, 50V	260844	06001	75F1R5A347	1		
C34	CAP, MYLAR, 0.1 UF +/-10%, 100V	393439	73445	C280MAH/A100K	REF		
C35	CAP, MYLAR, 0.033 UF +/-10%, 250V	234492	73445	C280MAE/A33K	REF		
C36	CAP, TA, ELECT, 15 UF +/-10%, 20V	153056	56289	150D156X0020B2	REF		
C37	CAP, TA, ELECT, 15 UF +/-10%, 20V	153056	56289	150D156X0020B2	REF		
C38	CAP, MICA, 4 PF +/-0.5%, 500V	190397	72136	DM15C040E	2		
C39	CAP, TA, ELECT, 15 UF +/-10%, 20V	153056	56289	150D156X0020B2	REF		
C40	CAP, MICA, 15 PF +/-5%, 500V	148569	72136	DM15C150J	REF		
C41	CAP, MYLAR, 0.022 UF +/-10%, 250V	234484	73445	C280MAE/A22K	REF		
C42	CAP, MYLAR, 0.0033 UF +/-10%, 50V	402867	06001	75F1R5A-333	REF		
C43	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D68X0035HA1	1		
C44	CAP, MICA, 4 PF +/-0.5%, 500V	190397	72136	DM15C040E	REF		
C45	CAP, MICA, 27 PF +/-5%, 500V	177998	72136	DM15F270J	REF		
C46	CAP, MICA, 15 PF +/-5%, 500V	148569	72136	DM15C150J	REF		
C47	CAP, MYLAR, 0.001 UF +/-10%, 200V	159582	56289	192P10292	1	1	
CL1	DIODE, FET, CURRENT REGULATOR	429373	89536	429373	1		
CR2	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	8	2	

Table 609A-6. RMS Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
CR3	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR5	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR6	DIODE, SI, LO-CAP, LO-LEAKAGE	375907	07263	FD7222	4	1	
CR7	DIODE, SI, LO-CAP, LO-LEAKAGE	375907	07263	FD7222	REF		
CR8	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR9	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR10	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR11	DIODE, ZENER	246611	07910	1N961B	4	1	
CR14	DIODE, SI, SM SIG	313247	28484	HP5082-6264	2	1	
CR15	DIODE, ZENER	246611	07910	1N961B	REF		
CR16	DIODE, SI, SM SIG	313247	28484	HP5082-6264	REF		
CR17	DIODE, SI, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR18	DIODE, ZENER	246611	07910	1N961B	REF		
CR19	DIODE, SI, 75 MA, 90 PIV	260554	07910	CD55105	1	1	
CR20	DIODE, SI, LO-CAP, LO-LEAKAGE	375907	07263	FD7222	REF		
CR21	DIODE, ZENER	260695	07910	1N754A	2	1	
CR22	DIODE, ZENER	260695	07910	1N754A	REF		
CR24	DIODE, ZENER	246611	07910	1N961B	REF		
CR25	DIODE, SI, LO-CAP, LO-LEAKAGE	375907	07263	FD7222	REF		
H1	SCREW, RH FILISTER, 6-32 X 1/2 (NOT SHOWN)	115006	89536	115006	3		
H2	SCREW, RHP, 4-40 X 3/8	256164	89536	256164	1		
K1	RELAY ASSY						
	COIL, REED RELAY	272070	71707	UD-6-P	2		
	SWITCH, DRY REED	219097	95348	MR5972	2		
	SWITCH, DRY REED	284091	95348	MR138	3		
	FOIL WRAP	313833	89536	313833	5		
	FOIL WRAP	313833	89536	313833	REF		
K2	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	1		
	SWITCH, DRY REED	284091	95348	MR138	REF		
	FOIL WRAP	313833	89536	313833	REF		
K4	RELAY, DRY REED	357566	71707	UF40069	4		
K5	RELAY, DRY REED	357566	71707	UF40069	REF		
K6	RELAY, DRY REED	357566	71707	UF40069	REF		
K7	RELAY ASSY						
	COIL, REED RELAY	272070	71707	UD-6-P	REF		
	SWITCH, DRY REED	219097	95348	MR5972	REF		
	SWITCH, DRY REED	284091	95348	MR138	REF		
	FOIL WRAP	313833	89536	313833	REF		
	FOIL WRAP	313833	89536	313833	REF		
K8	RELAY, DRY REED	357566	71707	UF40069	REF		
MP1	CASE ASSY (INCLUDES MP2-MP9)	425231	89536	425231	1		1
MP2	CASE HALF	402990	89536	402990	REF		
MP3	CASE HALF	402990	89536	402990	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	468462	89536	468462	REF		
MP6	DECAL, AC/DC CONVERTER (RMS)	413401	89536	413401	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		

Table 609A-6. RMS Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP10	FEED-THRU, TEFLON (NOT SHOWN)	281865	12615	SL-841-777	4		
MP11	HEATSINK	347740	05820	260-18D	1		
MP12	INSULATOR, SHIELD (NOT SHOWN)	426932	89536	426932	1		
MP13	SHIELD (NOT SHOWN)	416214	89536	416214	1		
MP14	SHIELD, INPUT	468470	89536	468470	1		
MP15	SOCKET (NOT SHOWN)	343285	00779	2-331272-6	7		
MP16	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	1		
MP17	STAND-OFF, TEFLON (NOT SHOWN)	275719	15849	1497B	5		
Q1	XSTR, FET, DUAL, N-CHANNEL	267963	89536	267963	1	1	
Q2	XSTR, FET, N-CHANNEL	343103	89536	343103	3	1	
Q4	XSTR, SI, NPN	218396	04713	2N3904	4	1	
Q6	XSTR, FET, N-CHANNEL	343103	89536	343103	REF		
Q7	XSTR, FET, N-CHANNEL	343103	89536	343103	REF		
Q8	XSTR, MATCHED SET (Q8 & Q12)	341057	89536	341057	1	1	2
Q10	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q11	XSTR, SI, PNP	195974	04713	2N3906	1	1	
Q12	XSTR, MATCHED SET (Q8 & Q12)	341057	89536	341057	REF		2
Q13	XSTR, FET, N-CHANNEL	288324	89536	288324	3	1	
Q14	XSTR, FET, N-CHANNEL	393314	89536	393314	1	1	
Q15	XSTR, SI, PNP	218388	07236	2N3645	1	1	
Q16	XSTR, FET, N-CHANNEL	288324	89536	288324	REF		
Q17	XSTR, FET, N-CHANNEL	288324	89536	288324	REF		
Q18	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q19	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q20	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
R1	RES, MTL. FILM, 1M +/-0.1%, 1W	340265	03888	PME75	1		
R2	RES, MTL. FILM, 16.9K +/-1%, 1/8W	267146	91637	CMF551692F	1		
R3	RES, DEP. CAR, 200 +/-5%, 1/4W	193482	80031	CR251-4-5P200E	1		
R4	THERMISTOR, TEMP SENS, NEG TC	501304	89536	501304	1		
R5	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	2		
R6	RES, MTL. FILM, 50K +/-0.1%, 1/8W	340257	91637	CMF555002B	3		
R7	RES, MTL. FILM, 50K +/-0.1%, 1/8W	340257	91637	CMF555002B	REF		
R8	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R9	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	6		
R10	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	1		
R11	RES, DEP. CAR, 12K +/-5%, 1/4W	348847	80031	CR251-4-5P12K	1		
R12	RES, VAR, CERMET, 1M +/-10%, 1/2W	334722	89536	334722	3		
R13	RES, MTL. FILM, 399.0K +/-0.1%, 1/8W	417212	91637	CMF553993B	1		
R14	RES, VAR, CERMET, 5K +/-10%, 1/2W	288282	89536	288282	1		
R15	RES, MTL. FILM, 56.89K +/-0.1%, 1/8W	417220	91637	CMF5556891B	1		
R16	RES, VAR, CERMET, 500 +/-10%, 1/2W	291120	89536	291120	1		
R17	RES, MTL. FILM, 6324 +/-0.1%, 1/8W	417238	91637	CMF556324B	1		
R18	RES, VAR, CERMET, 50 +/-10%, 1/2W	285122	89536	285100	2		
R19	RES, MTL. FILM, 782.8 +/-0.1%, 1/8W	417246	91637	CMF55782R8B	1		
R20	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	2		
R21	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	1		
R22	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	3		
R23	RES, MTL. FILM, 4.975K +/-0.1%, 1/8W	340232	91637	CMF554975B	1		

Table 609A-6. RMS Converter PCB Assembly (cont)

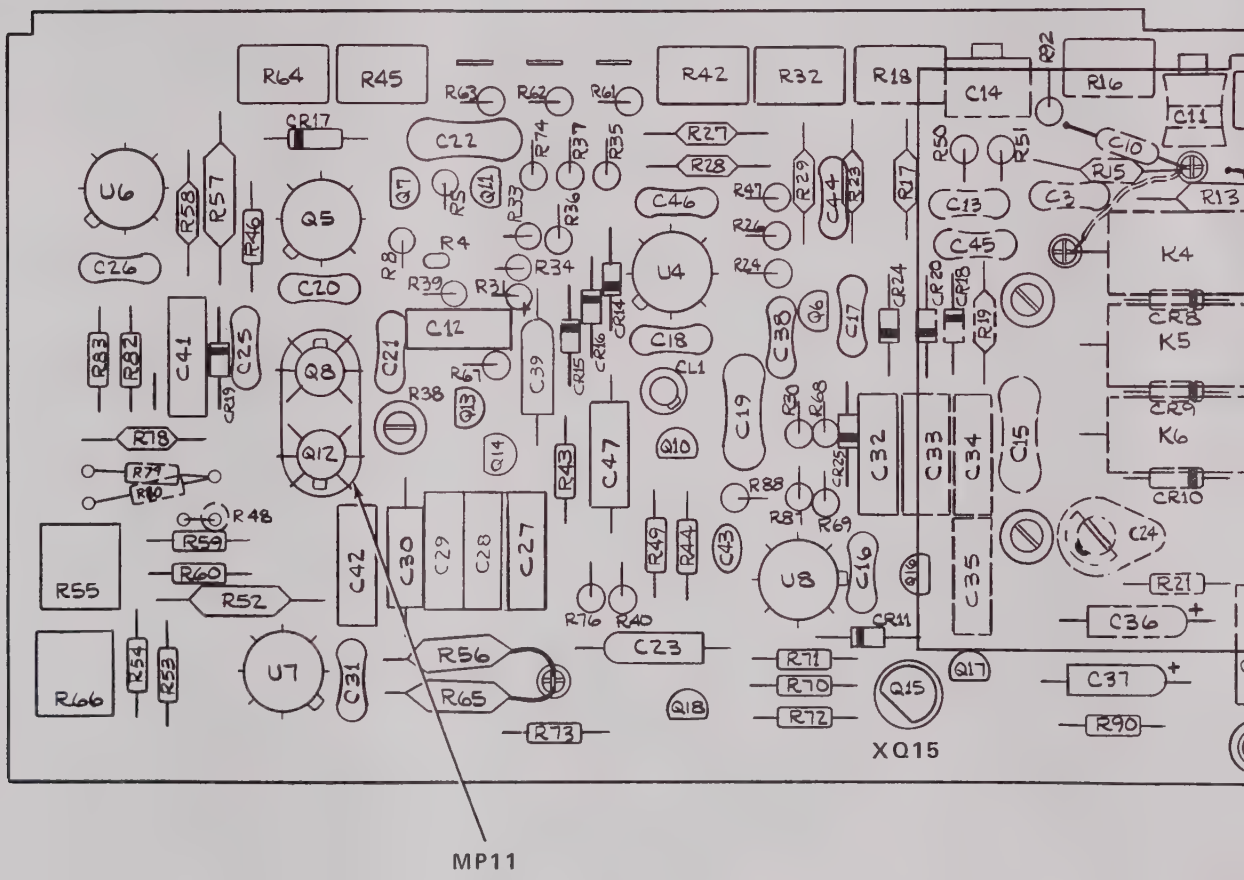
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R24	RES, DEP. CAR, 5.1K +/-5%, 1/4W	368712	80031	CR251-4-5P5K1	1		
R25	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	1		
R26	RES, DEP. CAR, 3.9K +/-5%, 1/4W	342600	80031	CR251-4-5P3K9	1		
R27	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	CMF551004F	2		
R28	RES, MTL. FILM, 121 +/-1%, 1/8W	343160	91637	CMF551210F	1		
R29	RES, MTL. FILM, 5K +/-0.1%, 1/8W	340240	91637	CMF555001B	1		
R30	RES, DEP. CAR, 5.6K +/-5%, 1/4W	442350	80031	CR251-4-5P5K6	3		
R31	RES, MTL. FILM, 50K +/-0.1%, 1/8W	340257	91637	CMF555002B	REF		
R32	RES, VAR, CERMET, 50 +/-10%, 1/2W	285122	89536	285100	REF		
R33	RES, MTL. FILM, 100K +/-0.1%, 1/8W	340166	91637	CMF551003B	1		
R34	RES, MTL. FILM, 35.7K +/-1%, 1/8W	288480	91637	CMF553572F	1		
R35	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R36	RES, DEP. CAR, 82 +/-5%, 1/4W	442277	80031	CR251-4-5P82E	1		
R37	RES, DEP. CAR, 5.6K +/-5%, 1/4W	442350	80031	CR251-4-5P5K6	REF		
R38	RES, VAR, CERMET, 3 +/-25%, 1/2W	347963	32997	3329H-J81-3R0	1		
R39	RESISTOR, SELECT						2
R40	RES, DEP. CAR, 5.6K +/-5%, 1/4W	442350	80031	CR251-4-5P5K6	REF		
R42	RES, VAR, CERMET, 1M +/-10%, 1/2W	334722	89536	334722	REF		
R43	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	3		
R44	RES, DEP. CAR, 9.1K +/-5%, 1/4W	441691	80031	CR251-4-5P9K1	1		
R45	RES, VAR, CERMET, 1M +/-10%, 1/2W	334722	89536	334722	REF		
R46	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	3		
R47	RES, DEP. CAR, 51K +/-5%, 1/4W	376434	80031	CR251-4-5P51K	1		
R48	RES, SELECTED						2
R49	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	REF		
R50	RES, CAR. DEP, 2.7 +/-5%, 1/4W	442061	80031	CR251-4-5P2E7	1		
R51	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R52	RES, MTL. FILM, 4.02M +/-1%, 1/4W	417253	91637	CMF604024F	1		
R53	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R54	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R55	RES, VAR, CERMET, 1M +/-10%, 1/2W	276691	89536	276691	2		
R56	RES, MTL. FILM, 2M +/-0.25%, 1/2W	327502	91637	CMF652004C	2		
R57	RES, MTL. FILM, 930K +/-0.25%, 1/4W	417345	91637	CMF609303C	1		
R58	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	CMF551004F	REF		
R59	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R60	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R61	RES, MTL. FILM, 17.4K +/-1%, 1/8W	236802	91637	CMF551742F	1		
R62	RES, MTL. FIL, 34K +/-1%, 1/8W	261602	91637	CMF553402F	1		
R63	RES, MTL. FILM, 68.1K +/-1%, 1/8W	236828	91637	CMF556812F	1		
R64	RES, VAR, CERMET, 20K +/-10%, 1.2W	291609	89536	291609	1		
R65	RES, MTL. FILM, 2M +/-0.25%, 1/2W	327502	91637	CMF652004C	REF		
R66	RES, VAR, CERMET, 1M +/-10%, 1/2W	276691	89536	276691	REF		
R67	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R68	RES, DEP. CAR, 200K +/-5%, 1/4W	441485	80031	CR251-4-5P200K	1		
R69	RES, DEP. CAR, 750K +/-5%, 1/4W	442525	80031	CR251-4-5P750K	1		
R70	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R71	RES, DEP. CAR, 470K +/-5%, 1/4W	342634	80031	CR251-4-5P470K	1		
R72	RES, DEP. CAR, 22K +/-5%, 1/4W	348870	80031	CR251-4-5P22K	1		
R73	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	1		
R74	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	2		

Table 609A-6. RMS Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R75	RES, VAR, CERMET, 10K +/-10%, 1/2W	285171	89536	285171	1		
R76	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R77	RES, MTL. FILM, 23.2K +/-1%, 1/8W	291351	91637	CMF552322F	1		
R78	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	CMF55A100F	1		
R79	RES, SELECTED						2
R80	RES, SELECTED						2
R81	RES, THERMISTOR, TEMP SENSITIVE	104596	73168	JA41J1	1		
R82	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R83	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	REF		
R84	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R85	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R86	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	2		
R87	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	3		
R88	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R89	RES, MTL. FILM, 42.2K +/-1%, 1/8W	221655	91637	CMF554222F	1		
R90	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R92	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
U1	⊗IC, C-MOS, NAND GATES	375147	02735	CD4023AE	1	1	
U2	IC, TTL, HEX INVERTER, BUFFER/DRIVER	288605	01295	SN7416N	1	1	
U3	IC, LIN, OP AMP	329912	12040	LM318H	1	1	
U4	IC, OP AMP	225961	24355	AD3092	1	1	
U5	IC, LIN, OP AMP	288928	12040	LM308AH	1	1	
U6	IC, LIN, OP AMP	284760	12040	LM308H	2	1	
U7	IC, LIN, OP AMP	284760	12040	LM308H	REF		
U8	IC, LIN, OP AMP	381889	12040	LM201AH	1	1	
U9	⊗IC, C-MOS, HEX BUFFER/INVERTER	381848	20735	CD4049AE	1	1	
U10	⊗IC, C-MOS, HEX "D" FLIP FLOP	404509	12040	MM74C174N	1	1	
U11	⊗IC, C-MOS, QUAD 2-INPUT NAND GATE	355198	04713	MC14011CD	1	1	
XQ15 Z	SPACER, COMPONENT	152207	07047	10123DAP	1		

1 SEE TABLE 5-17 AT THE END OF SECTION 5.

2 RESISTORS ARE TC COMPENSATED AND MUST BE RETURNED FOR RESELECTION IF ANY REQUIRE REPLACEMENT.


R64
R45
R63
R62
R61
R42
R32
R18
C14
R92
R16
C11
CR17
C22
R74
R37
R35
R27
R28
R50
R51
C10
R15
R13
U6
R58
R57
R46
Q5
Q7
R5
Q11
R33
R36
C46
R47
R29
C44
R23
R17
C13
C3
R4
R8
R39
R31
R34
R26
C45
K4
C26
C20
U4
R24
CR24
CR20
CR18
R19
CR8
K5
R83
R82
C41
C25
CR19
Q8
C12
C21
R67
C39
CR15
CR16
CR14
C18
Q6
C38
C17
CL1
C19
R38
Q13
R30
R68
CR29
K6
R78
Q12
Q14
R43
C47
Q10
CR25
C32
C33
C34
C15
R79
R80
R88
CR10
R48
R87
R69
C24
R55
R59
R60
R52
C42
C30
C29
C28
C27
R49
R44
C43
U8
C16
Q16
C35
R21
R76
R40
C36
CR11
R66
R54
R53
U7
C31
R56
R65
C23
R71
R70
R72
Q15
Q17
C37
Q18
R73
R90
XQ15
MP11

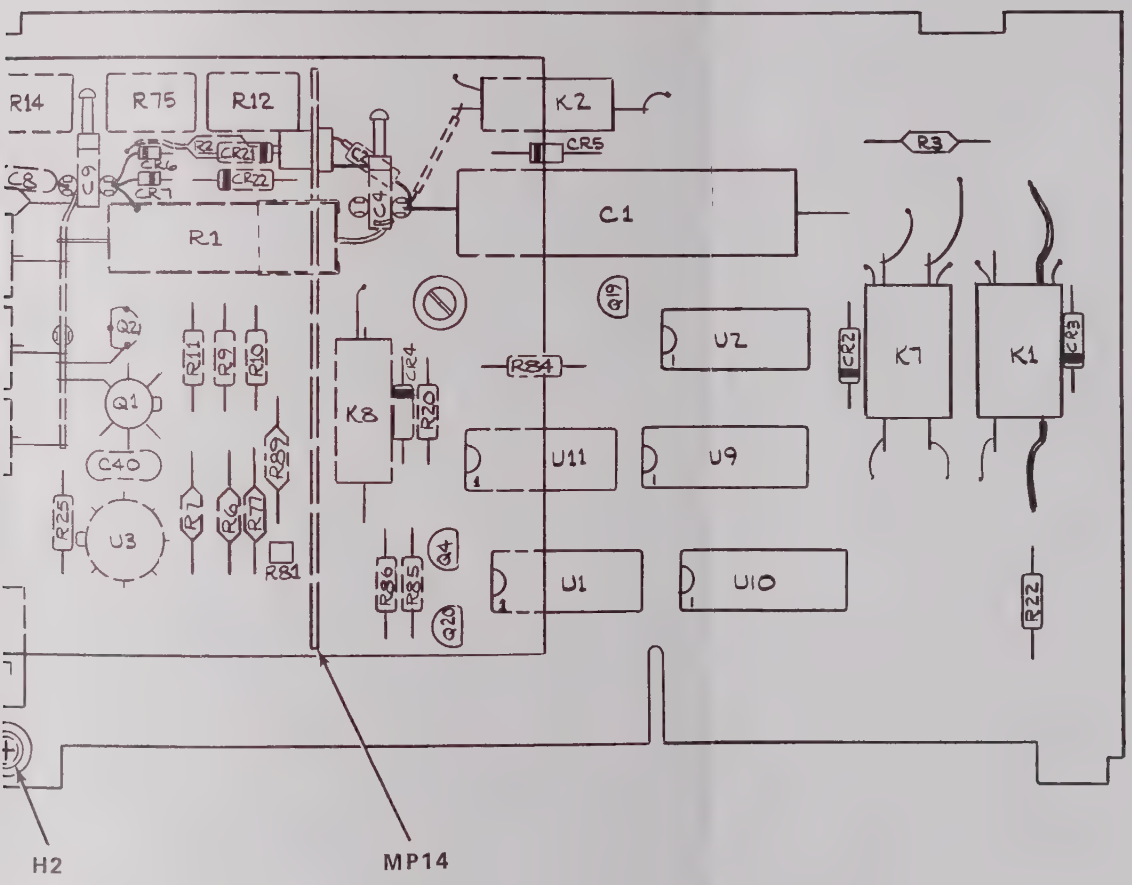
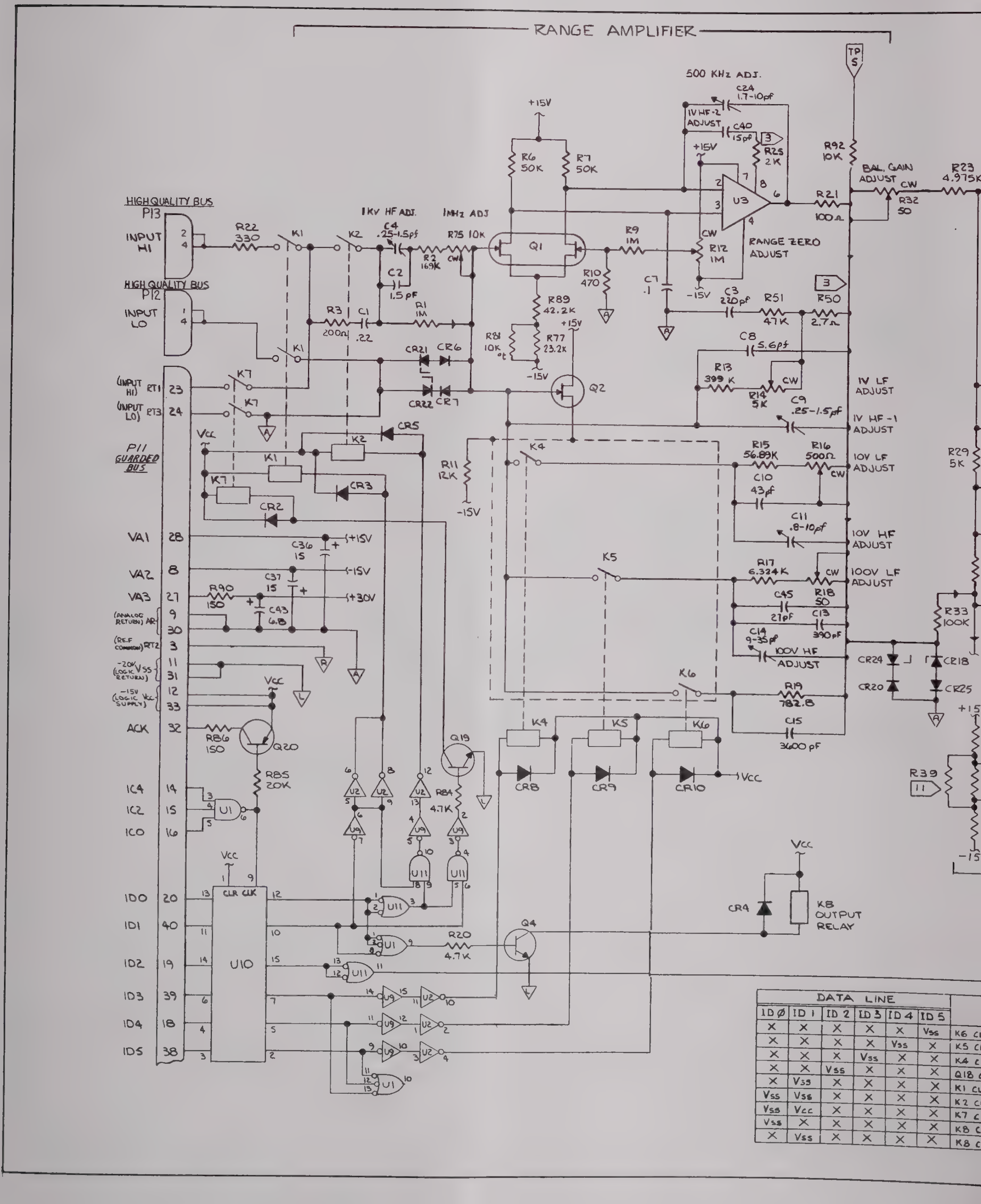
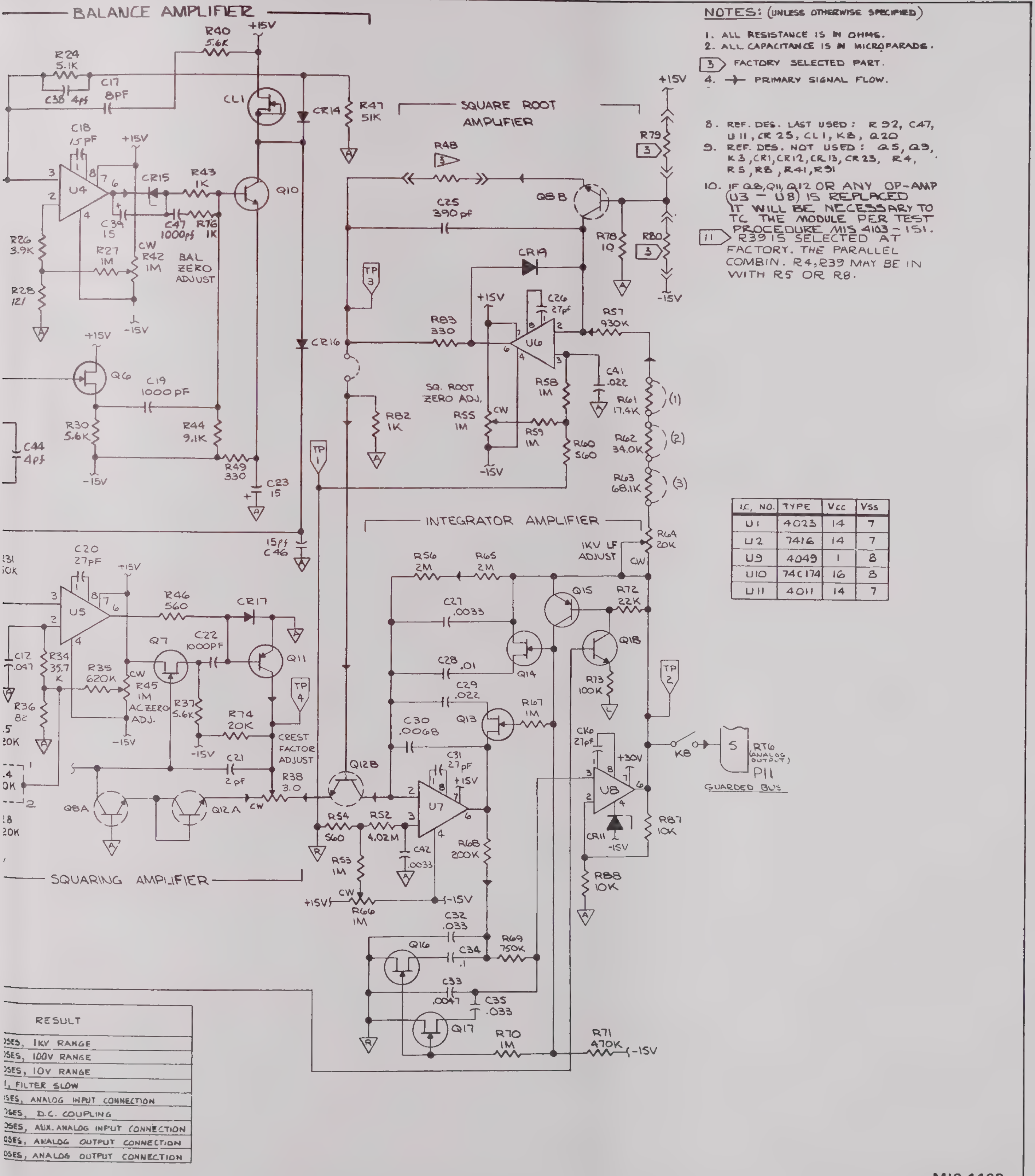

R14
R75
R12
K2
CR5
R3
R2
CR21
C8
U6
CR6
CR7
CR22
C4
C1
R1
Q19
Q2
U2
CR2
K7
K1
CR3
R11
R9
R10
R84
CR4
K8
R20
Q1
U11
U9
C40
R89
R25
U3
R7
R6
R77
R81
Q4
R86
R85
U1
U10
R22
Q20
H2
MP14
MIS-1703

Figure 609A-3. RMS Converter PCB Assembly


RANGE AMPLIFIER
TP 5
500 KHz ADJ.
C24 1.7-10pf
1V HF-2 ADJUST
C40 15pf
3
R25 2K
+15V
R6 50K
R7 50K
U3
RANGE ZERO ADJUST
R12 1M
CW
-15V
R92 10K
BAL. GAIN ADJUST
R32 50
R23 4.975K
R21 100Ω
HIGH QUALITY BUS P13
INPUT HI
R22 330
K1
K2
1KV HF ADJ.
1MHz ADJ
C4 .25-1.5pf
R2 169K
R75 10K
C2 1.5pF
Q1
R9 1M
R10 470
C7 .1
C3 220pf
R51 47K
R50 2.7Ω
R89 42.2K
R81 10K
R77 23.2K
HIGH QUALITY BUS P12
INPUT LO
R3 200Ω
C1 .22
R1 1M
CR21
CR6
CR22
CR7
Q2
C8 5.6pf
R13 399K
R14 5K
C9 .25-1.5pf
1V LF ADJUST
1V HF-1 ADJUST
(INPUT HI) RT1 23
(INPUT LO) RT3 24
K7
P11 GUARDED BUS
Vcc
CR5
CR3
CR2
R11 12K
-15V
K4
R15 56.89K
R16 500Ω
10V LF ADJUST
C10 43pf
C11 .8-10pf
10V HF ADJUST
R29 5K
K5
R17 6.324K
R18 50
100V LF ADJUST
C45 27pF
C13 390pF
C14 9-35pf
100V HF ADJUST
R33 100K
CR24
CR18
CR20
CR25
K6
R19 782.8
C15 3600 pF
VA1 28
VA2 8
VA3 27
C36 15
C37 15
C43 6.8
R90 150
+15V
-15V
+30V
(ANALOG RETURN) AR 9
30
(REF COMMON) RT2 3
-20V (LOGIC RETURN) Vss 11
31
-15V (LOGIC Vcc SUPPLY) 12
33
ACK 32
R86 150
Q20
R85 20K
IC4 14
IC2 15
IC0 16
U1
U2
U9
U11
Q19
R84 4.7K
CR8
CR9
CR10
R39
11
+15
-15
ID0 20
ID1 40
ID2 19
ID3 39
ID4 18
ID5 38
CLR CLK
U10
R20 4.7K
Q4
CR4
K8 OUTPUT RELAY

DATA LINE						
ID Ø	ID 1	ID 2	ID 3	ID 4	ID 5	
X	X	X	X	X	Vss	K6 C
X	X	X	X	Vss	X	K5 C
X	X	X	Vss	X	X	K4 C
X	X	Vss	X	X	X	Q18
X	Vss	X	X	X	X	K1 C
Vss	Vss	X	X	X	X	K2 C
Vss	Vcc	X	X	X	X	K7 C
Vss	X	X	X	X	X	K8 C
X	Vss	X	X	X	X	K8 C


BALANCE AMPLIFIER
R40 5.6K
+15V
R24 5.1K
C17 8PF
C38 4pf
CL1
CR14
R47 51K
C18 15pF
+15V
U4
CR15
R43 1K
Q10
C39 15
C47 1000pf
R76 1K
R26 3.9K
R27 1M
CW
R42 1M
BAL ZERO ADJUST
R28 121
-15V
+15V
Q6
C19 1000pF
R30 5.6K
R44 9.1K
C44 4pf
R49 330
-15V
C23 15
CR16
15pf C46
SQUARE ROOT AMPLIFIER
R48
3
R79
3
+15V
C25 390pf
Q8 B
R78 10
R80
3
CR19
TP 3
+15V
C26 27pf
R57 930K
R83 330
U6
C41 .022
SQ. ROOT ZERO ADJ.
R58 1M
R61 17.4K
(1)
R55 1M
CW
R59 1M
R82 1K
R60 560
R62 34.0K
(2)
-15V
TP 1
R63 68.1K
(3)
-15V
INTEGRATOR AMPLIFIER
1KV LF ADJUST
R64 20K
CW
C20 27pF
+15V
R56 2M
R65 2M
Q15
R72 22K
U5
R46 560
CR17
C27 .0033
Q18
Q7
C22 1000PF
Q11
C28 .01
Q14
C12 .047
R34 35.7K
R35 620K
CW
R45 1M
AC ZERO ADJ.
R37 5.6K
TP 4
C29 .022
R67 1M
R73 100K
TP 2
R36 82
R74 20K
C30 .0068
Q13
-15V
-15V
CREST FACTOR ADJUST
C31 27pF
C16 27pf
+30V
K8
5
RT6 (ANALOG OUTPUT)
P11
GUARDED BUS
C21 2pf
Q12B
+15V
U7
U8
R38 3.0
Q8A
Q12A
CW
R54 560
R52 4.02M
C42 .0033
R68 200K
CR11
-15V
R87 10K
SQUARING AMPLIFIER
R53 1M
CW
+15V
R66 1M
-15V
R88 10K
C32 .033
Q16
C34 .1
R69 750K
C33 .0047
C35 .033
Q17
R70 1M
R71 470K
-15V
MIS-1103

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICROFARADS.

3 FACTORY SELECTED PART.

4. ─┼─ PRIMARY SIGNAL FLOW.

8. REF. DES. LAST USED: R92, C47, U11, CR25, CL1, K8, Q20
9. REF. DES. NOT USED: Q5, Q9, K3, CR1, CR12, CR13, CR23, R4, R5, R8, R41, R91
10. IF Q8, Q11, Q12 OR ANY OP-AMP (U3 – U8) IS REPLACED IT WILL BE NECESSARY TO TC THE MODULE PER TEST PROCEDURE MIS 4103-151.

11 R39 IS SELECTED AT FACTORY. THE PARALLEL COMBIN. R4, R39 MAY BE IN WITH R5 OR R8.

I.C. NO.	TYPE	Vcc	Vss
U1	4023	14	7
U2	7416	14	7
U9	4049	1	8
U10	74C174	16	8
U11	4011	14	7

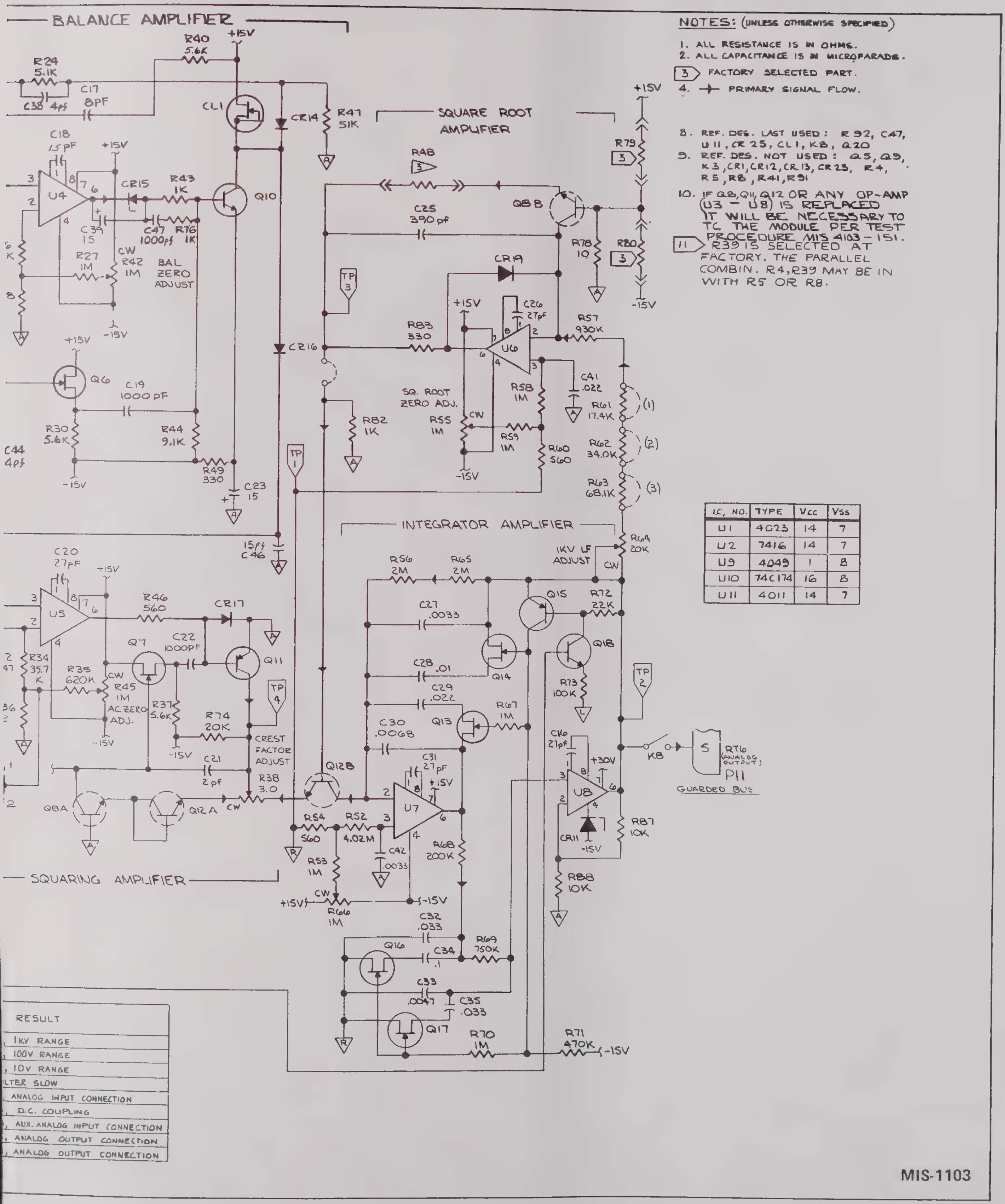
RESULT
SES, 1KV RANGE
SES, 100V RANGE
SES, 10V RANGE
, FILTER SLOW
SES, ANALOG INPUT CONNECTION
SES, D.C. COUPLING
SES, AUX. ANALOG INPUT CONNECTION
OSES, ANALOG OUTPUT CONNECTION
OSES, ANALOG OUTPUT CONNECTION

Figure 609A-3. RMS Converter PCB Assembly (cont)

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.


BALANCE AMPLIFIER
R40
5.6K
+15V
R24
5.1K
C17
8PF
C38 4pf
CL1
CR14
R47
51K
SQUARE ROOT
AMPLIFIER
C18
1.5 pF
+15V
U4
CR15
R43
1K
Q10
C39
15
C47
1000pf
R76
1K
R27
1M
CW
R42
1M
BAL
ZERO
ADJUST
-15V
+15V
Q6
C19
1000 pF
R30
5.6K
R44
9.1K
C44
4pf
-15V
R49
330
C23
15
R48
3
C25
390 pf
Q8B
R79
3
+15V
R78
10
R80
3
-15V
CR19
TP
3
+15V
C26
27pf
R83
330
U6
R57
930K
CR16
C41
.022
SQ. ROOT
ZERO ADJ.
R58
1M
R82
1K
R55
1M
CW
R59
1M
R61
17.4K
(1)
R62
34.0K
(2)
R60
560
-15V
TP
1
R63
68.1K
(3)
INTEGRATOR AMPLIFIER
15pf
C46
R64
20K
1KV LF
ADJUST
CW
C20
27pF
+15V
R56
2M
R65
2M
U5
R46
560
CR17
Q15
R72
22K
C27
.0033
Q7
C22
1000PF
Q11
Q18
R34
35.7
K
R35
620K
CW
R45
1M
AC ZERO
ADJ.
C28
.01
Q14
TP
4
TP
2
R37
5.6K
R73
100K
R74
20K
C29
.022
R67
1M
-15V
-15V
CREST
FACTOR
ADJUST
C30
.0068
Q13
C16
27pf
+30V
K8
S
RT6
(ANALOG OUTPUT)
P11
GUARDED BUS
C21
2 pf
R38
3.0
Q12B
C31
27pF
+15V
U8
Q8A
Q12A
CW
U7
R54
560
R52
4.02M
C42
.0033
CR11
-15V
R87
10K
R68
200K
R53
1M
R88
10K
SQUARING AMPLIFIER
+15V
CW
R66
1M
-15V
C32
.033
Q16
C34
.1
R69
750K
C33
.0047
C35
.033
Q17
R70
1M
R71
470K
-15V
MIS-1103

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICROFARADS.

3 FACTORY SELECTED PART.

4. ─┼─ PRIMARY SIGNAL FLOW.

8. REF. DES. LAST USED: R92, C47, U11, CR25, CL1, K8, Q20
9. REF. DES. NOT USED: Q5, Q9, K3, CR1, CR12, CR13, CR23, R4, R5, R8, R41, R91
10. IF Q8, Q11, Q12 OR ANY OP-AMP (U3 – U8) IS REPLACED IT WILL BE NECESSARY TO TC THE MODULE PER TEST PROCEDURE MIS 4103-151.

11 R39 IS SELECTED AT FACTORY. THE PARALLEL COMBIN. R4, R39 MAY BE IN WITH R5 OR R8.

I.C. NO.	TYPE	Vcc	Vss
U1	4023	14	7
U2	7416	14	7
U9	4049	1	8
U10	74C174	16	8
U11	4011	14	7

RESULT
1KV RANGE
100V RANGE
10V RANGE
LTER SLOW
ANALOG INPUT CONNECTION
D.C. COUPLING
AUX. ANALOG INPUT CONNECTION
ANALOG OUTPUT CONNECTION
ANALOG OUTPUT CONNECTION

Figure 609A-3. RMS Converter PCB Assembly (cont)

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
°C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
°F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(–) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmablle read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Federal Supply Codes for Manufacturers

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571
Use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
The Ross Milton Co.
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Div.
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, Massachusetts

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

Federal Supply Codes for Manufacturers (cont)

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Rectifier Division
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Div.
AMF Canada LTD.
Guelph, Ontario, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
The Budd Co. Polychem Products
Plastic Products Div.
Bridgeport, Pennsylvania

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
GTE Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

Federal Supply Codes for Manufacturers (cont)

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey
70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnback Radio Co., Inc.
Freeport, New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303
72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

Federal Supply Codes for Manufacturers (cont)

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp.
Mepco Div.
A North American Phillips Co.
Norristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Arnold Stevens, Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
The Carr Co., United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Div.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp.
of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
John Fluke Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

Federal Supply Codes for Manufacturers (cont)

90201
Mallory Capacitor Co.
Div. of P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211
Use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div. of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts, Div. of
Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

U.S. SALES AREAS for all Fluke products

AK, Anchorage
Harry Lang & Associates
1371 Hillcrest Drive #303
Anchorage, AK 99503
(907) 279-5741

AL, Huntsville
John Fluke Mfg. Co., Inc.
3322 S. Memorial Parkway
Suite 96
Huntsville, AL 35801
(205) 881-6220

AZ, Tempe
John Fluke Mfg. Co., Inc.
2125 S. 48th Street
Suite 104
Tempe, AZ 85282
(602) 967-8724
Tucson
(602) 790-9881

CA, Los Angeles
John Fluke Mfg. Co., Inc.
20902 South Bonita St.
Carson, CA 90746
(213) 538-3900
or (714) 761-2449

San Diego
John Fluke Mfg. Co., Inc.
9601 Aero Drive, Suite 290
San Diego, CA 92123
(714) 226-1254

Santa Clara
John Fluke Mfg. Co., Inc.
2300 Walsh Ave., Bldg. K
Santa Clara, CA 95051
(408) 727-0513

Tustin
John Fluke Mfg. Co., Inc.
15445 Red Hill Ave., Suite F
Tustin, CA 92680
(714) 838-8863

CO, Denver
John Fluke Mfg. Co., Inc.
1980 South Quebec St. #4
Denver, CO 80231
(303) 750-1222

CT, Hartford
John Fluke Mfg. Co., Inc.
Glen Locken East
41-C New London Turnpike
Glastonbury, CT 06033
(203) 659-3541

FL, Orlando
John Fluke Mfg. Co.,Inc.
940 N. Fern Creek Ave.
Orlando, FL 32803
(305) 896-4881

GA, Atlanta
John Fluke Mfg. Co., Inc.
2700 Delk Rd., Suite 250
Marietta, GA 30067
(404) 953-4747

HI, Honolulu
EMC Corporation
2979 Ualena St.
Honolulu, HI 96819
(808) 836-1138

IA, Iowa City
(319) 354-2811

IL, Chicago
John Fluke Mfg. Co., Inc.
3740 Industrial Ave.
Rolling Meadows, IL 60008
(312) 398-0850

IN, Indianapolis
John Fluke Mfg. Co., Inc.
877 Purdue
Suite 101
Indianapolis, IN 46268
(317) 875-7870

KS, Kansas City
John Fluke Mfg. Co., Inc.
4550 W. 109th St., Suite 130
Shawnee Mission, KA 66211
(913) 381-9800

LA, New Orleans
(504) 455-0814

MA, Burlington
John Fluke Mfg. Co., Inc.
25 "B" Street
Burlington MA 01803
(617) 273-4674

MD, Baltimore
(301) 792-7060

Rockville
John Fluke Mfg. Co., Inc.
5640 Fishers Lane
Rockville, MD 20852
(301) 770-1570

MI, Detroit
John Fluke Mfg. Co., Inc.
13955 Farmington Rd.
Livonia, MI 48154
(313) 522-9140

MN, Bloomington
John Fluke Mfg. Co., Inc.
1801 E. 79th St., Suite 9
Bloomington, MN 55420
(612) 854-5526

MO, St. Louis
John Fluke Mfg. Co., Inc.
2029 Woodland Parkway
Suite 105
St. Louis, MO 63141
(314) 993-3805

NC, Greensboro
John Fluke Mfg. Co., Inc.
1310 Beaman Place
Greensboro, NC 27408
(919) 273-1918

NJ, Paramus
John Fluke Mfg. Co., Inc.
P.O. Box 930
West 75 Century Road
Paramus, NJ 07652
(201) 262-9550

NM, Albuquerque
John Fluke Mfg. Co., Inc.
1108 Alvarado Drive N.E.
Albuquerque, NM 87110
(505) 881-3550

NY, Rochester
John Fluke Mfg. Co., Inc.
4515 Culver Road
Rochester, NY 14622
(716) 323-1400

OH, Cleveland
John Fluke Mfg. Co., Inc.
7830 Freeway Circle
Middleburg Heights, OH 44130
(216) 234-4540

Columbus
(614) 889-5715

Dayton
John Fluke Mfg. Co., Inc.
4756 Fishburg Rd.
Dayton, OH 45424
(513) 233-2238

OR, Portland
John Fluke Mfg. Co., Inc.
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Appendix 7A
Manual Change Information

INTRODUCTION

This appendix contains information necessary to backdate the manual to conform with earlier pcb configurations. To identify the configurations of the pcb's used in your instrument, refer to the revision letter (marked in ink) on the component side of each pcb assembly. Table 7A-1 defines the assembly revision levels documented in this manual with an X.

NEWER INSTRUMENTS

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pcb assembly. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted in the front of the manual.

OLDER INSTRUMENTS

To backdate this manual to conform with earlier assembly revision levels, perform the changes indicated in Table 7A-1.

CHANGES

There are no backdating changes at this printing. All pcb assemblies are documented at their original revision level.

OPTIONS

Change/errata information and backdating data for options will be included with the option instructions. These instructions are included with the option when shipped and can easily be added to the instrument's Instruction Manual.

Table 7A-1. Manual Status and Back Dating Information

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in descending order (by no.), ending with change under desired rev letter																				
			–	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	R				
A2	Motherboard Assy (8502-4001)	481713	2	1	◆	X																	
A3	Bus Interconnect (MIS-4081)	458636	X																				
A4	Power Supply (8500A-4041)	448886	●	●	5	4	3	◆	◆	X													
A4	Power Supply																						
A5	Power Supply Interconnect (8500A-4032)	401760	X																				
A6	Controller Assy (8502A-4185T)	384024	6	X																			
A6A1	Controller PCB (8502A-4185)	471318	9	◆	8	7	◆	X															
A6A2	PROM-ROM-RAM PCB (8502A-4088)	458141	●	10	◆	X																	
A6	Controller Assy																						
A7	Front Panel Display (8502A)-4023)	481689	11	◆	X																		
A8	DC Signal Conditioner (MIS-4100)	383901	●	●	●	●	●	●	●	●	15	14	13	◆	◆	◆	12	X					
A9	Active Filter (MIS-4130)	383976	●	●	●	●	●	◆	◆	16	X												
A10	A/D Converter Assy																						
A10A1	A/D Analog Assy (MIS-4140)	383752	●	●	●	●	●	●	●	●	●	●	●	18	◆	17	X						
A10A1	A/D Digital Assy (MIS-4141)	383760	●	●	20	◆	19	X															
01	AC/DC Converter (Averaging) (MIS-4101)		●	●	●	●	●	●	●	●	23	◆	◆	◆	22	21	X						
02	Ohms Converter (MIS-4110)		●	●	●	●	●	26	25	◆	24	X											
03	Current Shunts (MIS-4104)		●	●	●	●	●	●	●	29	◆	28	27	◆	X								
04	Calibration Memory (8500A-4160)		●	●	●	●	●	●	X														
			–	A	B	C	D	E	G	F	H	I	J	K	L	M	N	P	R				

* X = The PCB revision levels documented in this manual.
● = These revision letters were never used in the instrument.
– = No revision letter on the PCB.
◆ = This revision does not affect the manual.

Table 7A-1. Manual Status and Back Dating Information (cont)

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in descending order (by no.), ending with change under desired rev letter																					
			—	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	R					
05	IEEE-488 Interface (MB) (MIS-4172)		●	●	●	●	●	●	●	30	◆	X												
	IEEE-488 Interface (PB) (MIS-4072)		●	●	●	●	X																	
	IEEE-488 Interface (PB) (MIS-4074)		◆	31	X																			
06	Bit Serial Interface (MIS-4170)		●	●	●	●	●	●	●	●	●	◆	X											
07	Parallel Interface (MIS-4171)		●	●	●	●	33	32	X															
	Parallel Interface (MIS-4175)		◆	35	34	X																		
08A	Isolator (External Trigger) (8502A-4181)		37	36	X																			
09A	AC/DC Converter (RMS) (MIS-4103)		●	45	44	43	◆	42	41	40	39	38	X											
			—	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	R					

* X = The PCB revision levels documented in this manual.
● = These revision letters were never used in the instrument.
— = No revision letter on the PCB.
◆ = This revision does not affect the manual.

1. A2 Motherboard Assy (8502A-4001) — To modify from Rev B to Rev A:

DELETE THE FOLLOWING ITEMS:

H5	WASHER, FLAT, #8	110270	73734	1406	2
H6	WASHER, SPLIT	403923	89536	403923	2

2. A2 Motherboard Assy — To modify from Rev A to Rev —:

CHANGE J41 and J42 as follows:

FROM:	J41	BINDING POST, BLACK	493973	32767	820-45	1
	J42	BINDING POST, RED	493981	32767	820-65	1
TO:	J41	BINDING POST, BLACK	275560	32767	820-45	1
	J42	BINDING POST, RED	275552	32767	820-65	1

3. A4 Power Supply (8500A-4041) — To modify from Rev E to Rev D:

ADD THE FOLLOWING ITEM:

R1	RES, DEP CAR, 3.3K±5%, 1/4W	348813	80031	CR251-4-5P3K3	2

CHANGE the QTY of R2 from 1 to REF

DELETE THE FOLLOWING ITEMS:

R7	RES, DEP CAR, 240±5%, 1/4W	376624	80031	CR251-4-5P240E	1
R8	RES, DEP CAR, 2K±5%, 1/4W	441493	80031	CR251-4-5P2K	1
R9	RES, VAR, 500±20%, 1/2W	226068	19701	501	1

4. A4 Power Supply (8500A-4041) — to modify from Rev D to Rev C:

CHANGE BR4 as follows:

FROM:	BR4	BRIDGE RECTIFIER	428839	09713	MDA970-1	1
TO:	BR4	BRIDGE RECTIFIER	296509	09432	FB200	REF

CHANGE the QTY of BR1 from 4 to 3

5. A4 Power Supply (8500A-4041) — To modify from Rev C to Rev B:

CHANGE MP5 as follows:

FROM:	MP5	INSULATOR, MTG (NOT SHOWN)	508630	55285	7403-09FR-51	5
TO:	MP5	INSULATOR, MTG (NOT SHOWN)	428821	55285	7403-10-51	5

6. A6 Controller Assy (8502A-4185T) — To modify from Rev A to Rev —:

CHANGE U3 through U7 as follows:

FROM:	U3	PROM 2716	490003	89536	490003	1
	U4	PROM 2716	489997	89536	489997	1
	U5	PROM 2716	489989	89536	489989	1
	U6	PROM 2716	489971	89536	489971	1
	U7	PROM 2716	489963	89536	489963	1
TO:	U3	PROM 2716	472225	89536	472225	1

U4	PROM 2716	472233	89536	472233	1
U5	PROM 2716	472241	89536	472241	1
U6	PROM 2716	472258	89536	472258	1
U7	PROM 2716	472266	89536	472266	1

DELETE THE FOLLOWING ITEM:

U8	PROM 2716	489955	89536	489955	1

7. A6A1 Controller PCB (8502A-4185) — To modify from Rev D to Rev C:

CHANGE R26 as follows:

FROM:	R26	RES, CAR DEP, 47K±5%, 1/4W	348896	80031	CR251-4-5P47K	1
TO:	R26	RES, CAR DEP, 30K±5%, 1/4W	368753	80031	CR251-4-5P30K	1

8. A6A1 Controller PCB (8502A-4185) — To modify from Rev C to Rev B:

CHANGE C8 as follows:

FROM:	C8	CAP	148569			1
TO:	C8	CAP, MICA, 4PF±0.5PF, 500V	190397	72136	DM15C040E	2

CHANGE the quantity of R9 from 1 to REF

CHANGE the times noted in the ϕ pulse train of Figure 4-6 as follows:

FROM:	≥60ns	TO: >70ns
FROM:	80±ns	TO: blank
FROM:	95±5ns	TO: ≥ns (no overlap)
FROM:	588ns	TO: 508ns

9. A6A1 Controller PCB (8502A-4185) — To modify from Rev A to Rev —:

CHANGE C1 as follows:

FROM:	C1	CAP, MICA, 22PF±5%, 500V	148551	72136	DM15E220J	1
TO:	C1	CAP, MICA, 15PF±5%, 500V	148569	72136	DM15C150J	1

DELETE THE FOLLOWING ITEM:

CR2	DIODE, SI, HI-SPEED SWITCHING	203323	07910	IN4448	1

10. A6A2 PROM ROM PCB (8502A-4088) — To modify from Rev B to Rev A:

DELETE THE FOLLOWING ITEM:

C8	CAP, CER, 0.22UF±20%, 25V	309849	71590	CW30C224K	REF

CHANGE the quantity of C3 from 6 to 5

11. A7 Front Panel Display (8502A-4023) — To modify from Rev A to Rev —:

CHANGE H1 as follows:

FROM:	H1	SPACER (NOT SHOWN)	448432	89536	448432	1
TO:	H1	SPACER (NOT SHOWN)	446641	11897	167-PB-0588	1

12. A8 DC Signal Conditioner (MIS-4100) — To modify Rev R to Rev P:

CHANGE Q18 as follows:

FROM:	Q18		585109			1
TO:	Q18	TRANSISTOR, NPN, SI	284075	32293	IT1099	1

13. A8 DC Signal Conditioner (MIS-4100) — To modify Rev L to Rev K:

DELETE THE FOLLOWING ITEM:

CR5	DIODE	348177	XXXXX1		1

14. A8 DC Signal Conditioner (MIS-4100) — To modify Rev K to Rev J:

CHANGE U3 and U4 as follows:

FROM:	U3	IC, OP AMP, J-FET	357830	12040	LH0042C	2	1
	U4	IC, OP AMP, J-FET	357830	12040	LH0042C	REF	
TO:	U3	IC, OP AMP, J-FET	310037	12040	LH0042CH	2	1
	U4	IC, OP AMP, J-FET	310037	12040	LH0042CH	REF	

15. A8 DC Signal Conditioner (MIS-4100) — To modify Rev J to Rev H:

CHANGE K1 and K2 as follows:

FROM:	K1	RELAY, ARMATURE, LO-PROFILE	515437	89536	515437	2
	K2	RELAY, ARMATURE, LO-PROFILE	515437	89536	515437	REF
TO:	K1	RELAY, ARMATURE, LO-PROFILE	441261	77342	R40-E0186-1	2
	K2	RELAY, ARMATURE, LO-PROFILE	441261	77342	R40-E0186-1	REF

16. A9 Active Filter (MIS-4130) — To modify Rev H to Rev G:

DELETE the following item and change the quantity of Q14 from 15 to 14:

Q33	TRANSISTOR, FET, N-CHANNEL	393314	89536	393314	REF

17. A10A1 A/D Analog Assy (MIS-4140) — To modify Rev P to Rev N:

CHANGE R25 and R26 as follows:

FROM:	R25	RES, MF, 42.2K±1%, 1/8W	221655	91637	MFF1-84222F	2
	R26	RES, MF, 42.2K±1%, 1/8W	221655	91637	MFF1-84222F	REF
TO:	R25	RES, MF, 49.9K±1%, 1/8W	268821	91637	MFF1-84992F	2
	R26	RES, MF, 49.9K±1%, 1/8W	268821	91637	MFF1-84992F	REF

18. A10A1 A/D Analog Assy (MIS-4140) — To modify Rev M to Rev L:

DELETE the following items and change the quantity of C16 from 4 to 2:

C22	CAP, CER, 0.22UF±20%, 50V	309849	71590	CW30C224K	REF
C23	CAP, CER, 0.22UF±20%, 50V	309849	71590	CW30C224K	REF

19. A10A2 A/D Digital Assy (MIS-4141) — To modify Rev E to Rev D:

CHANGE U38 as follows:

FROM:	U38	IC, LINEAR, 5XSTR ARRAY	477778	89536	477778	REF
TO:	U38	IC, LINEAR, 5SXTR ARRAY	380188	02735	CA318E	REF

CHANGE the quantity of U14 from 3 to 4.
CHANGE the quantity of U23 from 2 to 1.

20. A10A2 A/D Digital Assy (MIS-4141) — to modify Rev C to Rev B:

CHANGE U23 as follows and change the quantity of U14 from 4 to 5

FROM:	U23	IC, LINEAR, 5XSTR ARRAY	477778	89536	477778	1
TO:	U23	IC, LINEAR, 5XSTR ARRAY	380188	02735	CA3183	REF

21. Opt -01 AC/DC Converter (Averaging) (MIS-4101) — To modify Rev P to Rev N:

CHANGE R3 as follows:

FROM:	R3	RES, DEP CAR, 120K±5%, 1/4W	441386	80031	CR251-4-5P120K	2
TO:	R3	RES, DEP CAR, 270K±5%, 1/4W	348961	80031	CR251-4-5P270K	1

CHANGE the quantity of R50 from REF to 1.

22. Opt -01 AC/DC Converter (Averaging) (MIS-4101) — To modify Rev N to Rev M:

CHANGE R3 as follows:

FROM:	R3	RES, DEP CAR, 270K±5%, 1/4W	348961	80031	CR251-4-5P270K	1
TO:	R3	RES, MF, 221K±1%, 1/2W	182527	91637	CMF651-2-1P221K	1

DELETE R55 as follows and change the quantity of R17 from 3 to 2:

	R55	RES, VAR, CERMET, 100K±10%, 1/2W	288308	89536	288308	REF

23. Opt -01 AC/DC Converter (Averaging) (MIS-4101) — To modify Rev N to Rev M:

CHANGE R3 as follows:

FROM:	R3	RES, MF, 221K±1%, 1/2W	182527	91637	CMF651-2-1P221K	1
TO:	R3	RES, COMP, 120K±5%, 1/4W	193458	01121	CB1245	1

CHANGE R19 as follows:

FROM:	R19	RES, VAR, CERMET, 5K±10%, 1/2W	288282	89536	288282	1
TO:	R19	RES, VAR, CERMET, 2K±10%, 1/2W	285163	89536	285163	1

CHANGE R13 as follows and change the quantity of R26 from 3 to REF

FROM:	R13	RES, DEP CAR, 75K±5%, 1/4W	394130	80031	CR251-4-5P75K1	
TO:	R13	RES, DEP CAR, 47K±5%, 1/4W	348896	80031	CR251-4-5P47K	4

CHANGE the quantity of SOCKET, COMPONENT LEAD (343285) from 8 to 4:

24. Opt -02 Ohms Converter (MIS-4110) — to modify from Rev J to Rev H

CHANGE R14 as follows:

FROM:	R14	RES, DEP CAR, 20K±5%, 1/4W	441477	80031	CR251-4-5P20K	1
TO:	R14	RES, DEP CAR, 120K±5%, 1/4W	441386	80031	CR251-4-5P120K	5

CHANGE the quantity of R47 from 4 to REF.

25. Opt -02 Ohms Converter (MIS-4110) — To modify from Rev G to Rev F:

CHANGE K1 as follows:

FROM:	K1	RELAY ARMATURE	515429	89536	515437	1
TO:	K1	RELAY ARMATURE	441261	77342	R40-E0186-1	1

26. Opt -02 Ohms Converter (MIS-4110) — To modify from Rev F to Rev E:

CHANGE R63, R64, and R65 as follows:

FROM:	R63	RES, MF, 15.8K±1%, 1/8W	293688	91637	MFF1-81582F	1
	R64	RES, MF, 73.2K±1%, 1/8W	237222	91637	MFF1-87322F	1
	R65	RES, MF, 30.1K±1%, 1/8W	168286	91637	MFF1-83012F	1
TO:	R63	RES, MF, 28K±1%, 1/8W	291835	91637	MFF1-82802F	1
	R64	RES, MF, 21K±1%, 1/8W	229484	91637	MFF1-82102F	1
	R65	RES, MF, 17.8K±1%, 1/8W	349183	91637	MFF1-81782F	1

27. Opt -03 Current Shunts (MIS-4104) — To modify from Rev L to Rev K:

DELETE C14 as follows:

C14	CAP, MICA, 390PF±5%, 500V	148437	72316	DM15F391J	1

28. Opt -03 Current Shunts (MIS-4104) — To modify from Rev K to Rev J:

CHANGE CR5, CR6, CR7, CR8, CR9, CR10, as follows:

FROM:	CR5	DIODE, SI, 1A, 600 PIV	112383	05277	FN4822	6
	CR6	DIODE, SI, 1A, 600 PIV	112383	05277	FN4822	REF
	CR7	DIODE, SI, 1A, 600 PIV	112383	05277	FN4822	REF
	CR8	DIODE, SI, 1A, 600PIV	112383	05277	FN4822	REF
	CR9	DIODE, SI, 1A, 600 PIV	112383	05277	FN4822	REF
	CR1	DIODE, SI, 1A, 600 PIV	112383	05277	FN4822	REF
TO:	CR5	DIODE, SI, RECT	347559	05277	1N5400	6
	CR6	DIODE, SI, RECT	347559	05277	1N5400	REF
	CR7	DIODE, SI, RECT	347559	05277	1N5400	REF
	CR8	DIODE, SI, RECT	347559	05277	1N5400	REF
	CR9	DIODE, SI, RECT	347559	05277	1N5400	REF
	CR1	DIODE, SI, RECT	347559	05277	1N5400	REF

29. Opt -03 Current Shunts (MIS-4104) — to modify from Rev H to Rev G:

DELETE C12 and C13 as follows:

C12	CAP, CER, 0.22UF±20%, 50V	309849	71590	CW30C224K	2
C13	CAP, CER, 0.22UF±20%, 50V	309848	71590	CW30224K	REF

30. Opt -05 IEEE-488 Interface (MIS-4172) — To modify from Rev H to Rev G:

CHANGE J3 as follows:

FROM:	J3	CONNECTOR,	534107			1
TO:	J3	CONN, CABLE, 24-PIN, MODIFIED	441337	02660	57-20240-14	1

31. Opt -05 IEEE-488 Interface (MIS-4074) — To modify from Rev B to Rev A:

CHANGE P2 and P2-1 as follows:

FROM:	P2		447110			1
	P2-1 1		447102			1
TO:	P2	CONNECTOR, SOCKET, 4-PIN	417311	20447	SS-109-1-04	5
	P2-1	CONNECTOR, SOCKET, 12-PIN	417733	20447	SS-109-1-12	3

32. Opt -07 Parallel Interface (MIS-4171) — To modify from Rev F to Rev E:

CHANGE J2 as follows:

FROM:	J2	CONNECTOR			447110	2
	J2	SOCKET, 12-PIN	425744	89536	425744	2
TO:	J2-1	SOCKET, 4-PIN	417311	20447	SS-109-1-041	4

33. Opt -07 Parallel Interface (MIS-4171) — to modify from Rev E to Rev D:

DELETE R7 as follows:

	R7	DEP CAR, 100K±5%, 1/4W	348920	80031	CR251-4-5P100K	1

34. Opt -07 Parallel Interface (MIS-4175) — To modify from Rev C to Rev B:

CHANGE J2 as follows:

FROM:	J2	CONNECTOR			447110	2
	J2	SOCKET, 12-PIN	425744	89536	425744	2
TO:	J2-1	SOCKET, 4-PIN	417311	20447	SS-109-1-041/4	

35. Opt -07 Parallel Interface (MIS-4175) — To modify from Rev B to Rev A:

DELETE R7 as follows:

	R7	DEP CAR, 100K±5%, 1/4W	348920	80031	CR251-4-5P100K	1

36. Opt -08A Isolator (External Trigger) (8502A-4181) — To modify from Rev B to Rev A:

DELETE L1 as follows:

	L1	CHOKE, 6-TURN	320911	89536	320911	1

37. Opt -08A Isolator (External Trigger) (8502A-4181) — To modify from Rev A to Rev —:

CHANGE R18 as follows:

FROM:	R18	RES, DEP CAR, 100K±5%, 1/4W	348920	80031	CR251-4-5P100K	1
TO:	R18	RES, DEP CAR, 100±5%, 1/4W	348771	80031	CR251-4-5P100E	1

38. Opt -09A AC/DC Converter (RMS) (MIS-4103) — To modify from Rev K to Rev J:

CHANGE C39 as follows:

FROM:	C39	CAP, TA, ELECT, 15UF±10%, 20V	153056	56289	150D156X9020B2	REF	
TO:	C39	CAP, MYLAR, 0.1UF±10%, 100V	393439	73445	C280MAH/A100K	REF	

CHANGE the quantity of C3 from 4 to 3.
CHANGE the quantity of C7 from 2 to 3.

39. Opt -09A AC/DC Converter (RMS) (MIS-4103) — To modify from Rev J to Rev H:

CHANGE R3 as follows:

FROM:	R3	RES, DEP CAR, 200±5%, 1/4W	441451	80031	CR251-4-5P200E	1	
TO:	R3	RES, COMP, 200 ±5%, 1/2W	169839	01121	EB2015	1	

40. Opt-09A AC/DC Converter (RMS) (MIS-4103) — To modify from Rev H to Rev G:

CHANGE R14 as follows:

FROM:	R14	RES, VAR, CER, 5K±10%, 1/2W	288282	89536	288282	1	1
TO:	R14	RES, VAR, CERMET, 2K±10%, 1/2W	285163	89536	285163	1	1

41. Opt -09A AC/DC Converter (RMS) (MIS-4103) — To modify from Rev G to Rev F:

CHANGE CL1 as follows:

FROM:	CL1	DIODE, FET, CURRENT REGULATOR	429373	89536	429373	1	
TO:	CL1	DIODE, FET, CURRENT REGULATOR	285106	07910	1CR5309	1	

42. Opt -09A AC/DC Converter (RMS) (MIS-4103) — To modify from Rev F to Rev E:

CHANGE U5 as follows:

FROM:	U5	IC, LIN, OP AMP	418368	12040	LM208A	1	1
TO:	U5	IC, LIN, OP AMP	288928	12040	LM308AH	1	1

43. Opt 09A AC/DC Conerter (RMS) (MIS-4103) — To modify from Rev D to Rev C:

CHANGE R25 as follows:

FROM:	R25	RES, DEP CAR, 2K±5%, 1/4W	441469	80031	CR251-4-5P2K	1	
TO:	R25	RES, COMP 3K±5%, 1/4W	193508	01121	CB3025	1	

44. Opt -09A AC/DC Converter (RMS) MIS-4103) — To modify from Rev C to Rev B:

CHANGE R3 as follows:

FROM:	R3	RES, COMP, 200±5%, 1/2W	169839	01121	EB2015	1	
TO:	R3	RES, MF, 2K±1%, 1/8W	235226	91637	CMF552001F	1	

CHANGE R2 as follows:

FROM:	R2	RES, MF, 13K±1%, 1/8W	335539	91637	CMF551302F	1	
TO:	R2	RES, MF, 16.9k±1%, 1/8W	267146	91637	CMF551692F	1	

45. Opt -09A AC/DC Converter (RMS) (MIS-4103) — To modify from Rev B to Rev A:

CHANGE C18 as follows:

FROM:	C18	CAP, MICA, 15PF±5%, 500V	148569	72136	DM15C150J	3
TO:	C18	CAP, MICA, 27PF±5%, 500V	177998	72136	DM15F270J	REF

CHANGE the quantity of C16 from 5 to 6.
CHANGE the quantity of C40 from REF to 2.

Section 8

Schematic Diagrams

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List of Mnemonics

ACK	— acknowledge
ACK LAT	— acknowledge late
AR	— analog return
DB	— data bus
DBIN	— data bus input signal (from μP)
DLD ACK	— delayed ACK
EN INT	— enable interrupt
HLDA	-- hold acknowledge
IB ADX	— interbus address
IBIN	— interbus input signal
IC	— interbus control
ID	— interbus data
IINT	— internal interrupt
INA	— interrupt acknowledge (from controller)
INT	— interrupt
INTA	— Interrupt acknowledge (status word from μP)
INTE	— interrupt enable (from μP)
MEM RD	— memory read
MS ADDR BYTE	— memory select address byte
ϕ1	— clock pulse
ϕ2	— clock pulse
ϕLL	— phase-locked loop
RAM	— random access memory
ROM	— read only memory
RRDY	— reset ready
RST	— reset
RT	— real time
R/W	— read/write
μP	– microprocessor
VA	— analog supply voltage
$V_{CC}\ \phi2$	— 5V clock pulse
$V_{DD}\ \phi2$	— 12V clock pulse
SRDY	— set ready
SYN IINT	— synchronized internal interrupt
TTL PU	— TTL pull-up
WO	— write out
WR	— write

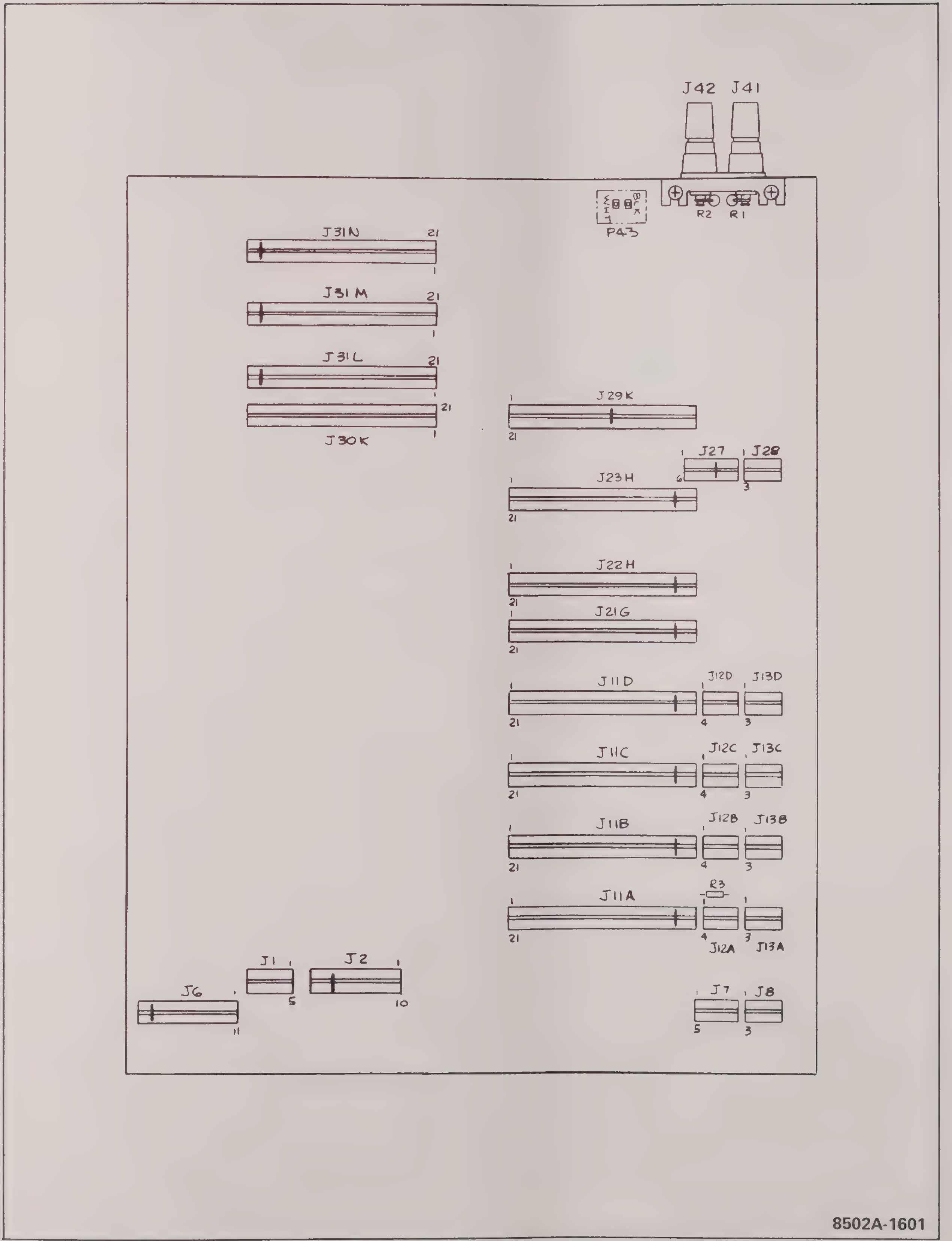
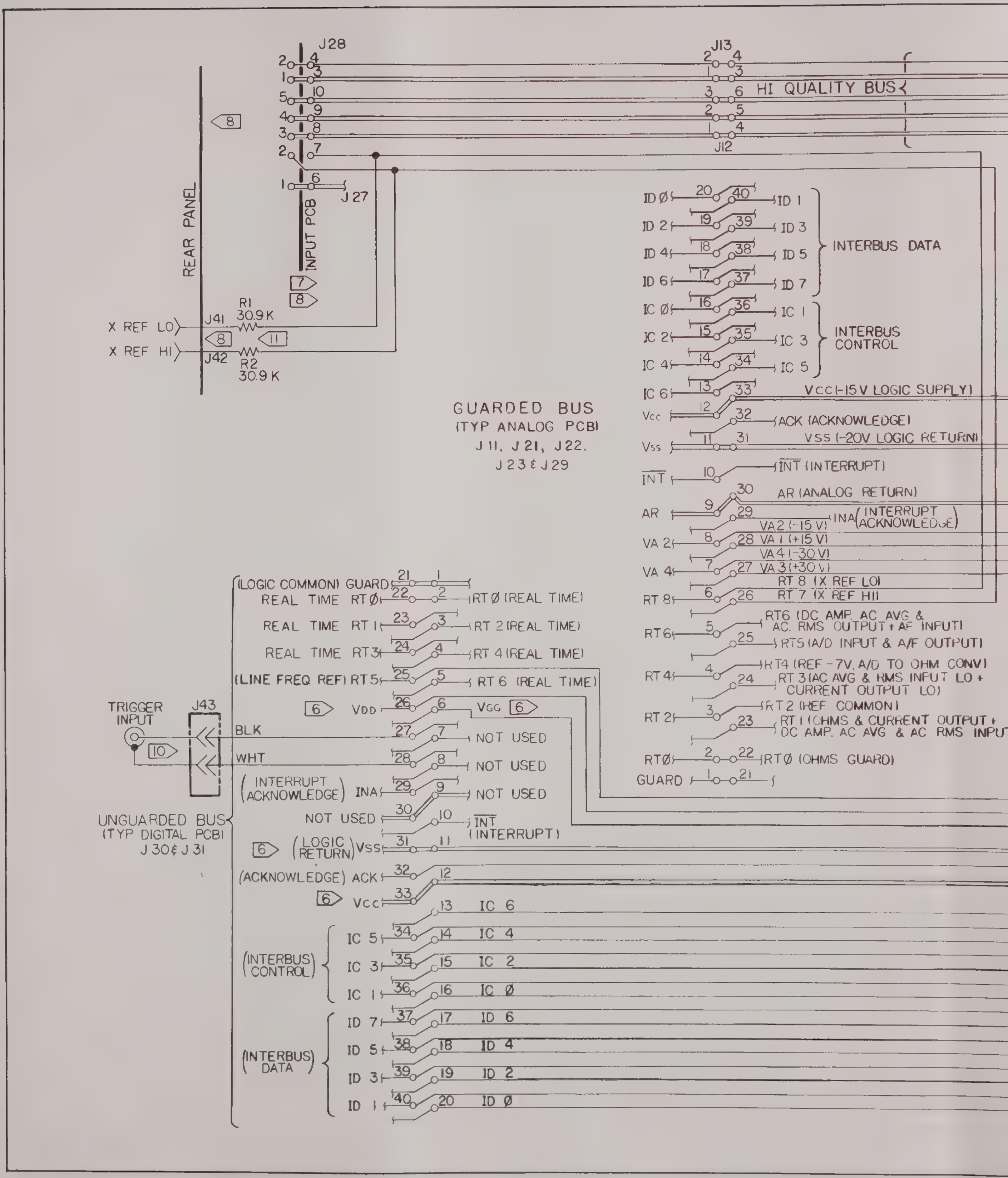
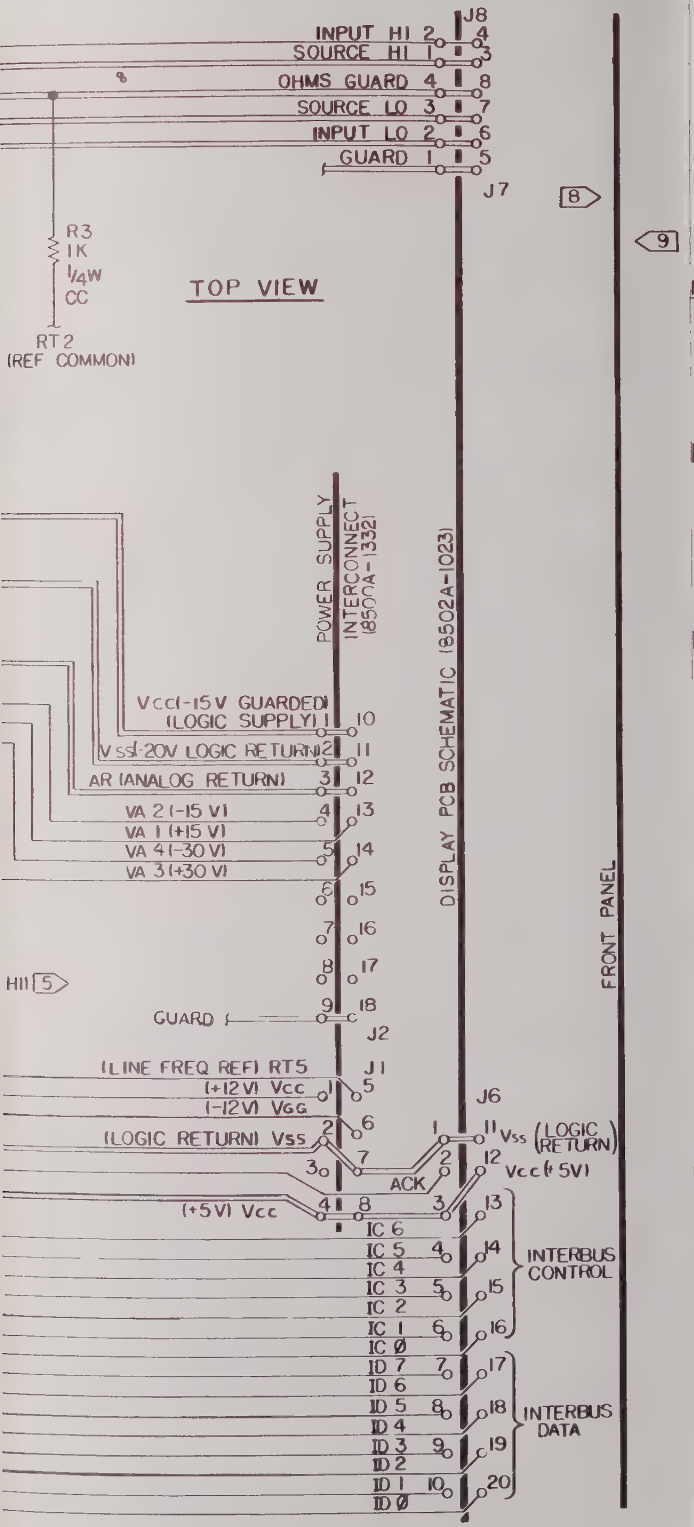

J42
J41
P43
R2
R1
J31N
J31M
J31L
J30K
J29K
J27
J28
J23H
J22H
J21G
J11D
J12D
J13D
J11C
J12C
J13C
J11B
J12B
J13B
J11A
R3
J12A
J13A
J1
J2
J6
J7
J8
8502A-1601

Figure 8-1. A2 Motherboard PCB Assembly


J28
J13
J12
J27
HI QUALITY BUS
REAR PANEL
INPUT PCB
8
7
11
10
6
X REF LO
X REF HI
J41
J42
R1 30.9 K
R2 30.9 K
GUARDED BUS (TYP ANALOG PCB) J11, J21, J22, J23 & J29
ID 0
ID 1
ID 2
ID 3
ID 4
ID 5
ID 6
ID 7
INTERBUS DATA
IC 0
IC 1
IC 2
IC 3
IC 4
IC 5
IC 6
INTERBUS CONTROL
VCC (-15 V LOGIC SUPPLY)
Vcc
ACK (ACKNOWLEDGE)
Vss
VSS (-20V LOGIC RETURN)
INT
INT (INTERRUPT)
AR
AR (ANALOG RETURN)
INA (INTERRUPT ACKNOWLEDGE)
VA 2
VA 2 (-15 V)
VA 1 (+15 V)
VA 4
VA 4 (-30 V)
VA 3 (+30 V)
RT 8
RT 8 (X REF LO)
RT 7 (X REF HI)
RT 6
RT6 (DC AMP. AC AVG & AC. RMS OUTPUT + AF INPUT)
RT5 (A/D INPUT & A/F OUTPUT)
RT 4
RT4 (REF -7V, A/D TO OHM CONV)
RT 3 (AC AVG & RMS INPUT LO + CURRENT OUTPUT LO)
RT 2
RT 2 (REF COMMON)
RT 1 (OHMS & CURRENT OUTPUT + DC AMP. AC AVG & AC RMS INPU
RT0
RT0 (OHMS GUARD)
GUARD
(LOGIC COMMON) GUARD
REAL TIME RT0
RT 0 (REAL TIME)
REAL TIME RT 1
RT 2 (REAL TIME)
REAL TIME RT3
RT 4 (REAL TIME)
(LINE FREQ REF) RT 5
RT 6 (REAL TIME)
VDD
VGG
TRIGGER INPUT
J43
BLK
WHT
NOT USED
(INTERRUPT ACKNOWLEDGE) INA
NOT USED
INT (INTERRUPT)
UNGUARDED BUS (TYP DIGITAL PCB) J 30 & J 31
(LOGIC RETURN) VSS
(ACKNOWLEDGE) ACK
VCC
(INTERBUS CONTROL)
IC 5
IC 3
IC 1
IC 6
IC 4
IC 2
IC 0
(INTERBUS DATA)
ID 7
ID 5
ID 3
ID 1
ID 6
ID 4
ID 2
ID 0


J8
INPUT HI 2 4
SOURCE HI 1 3
OHMS GUARD 4 8
SOURCE LO 3 7
INPUT LO 2 6
GUARD 1 5
J7
8
9
R3
1K
1/4W
CC
RT2
(REF COMMON)
TOP VIEW
POWER SUPPLY INTERCONNECT (8500A-1332)
DISPLAY PCB SCHEMATIC (8502A-1023)
FRONT PANEL
Vcc(-15V GUARDED) (LOGIC SUPPLY) 1 10
Vss(-20V LOGIC RETURN) 2 11
AR (ANALOG RETURN) 3 12
VA 2 (-15 V) 4 13
VA 1 (+15 V)
VA 4 (-30 V) 5 14
VA 3 (+30 V)
6 15
7 16
8 17
HI 5
GUARD 9 18
J2
J1
(LINE FREQ REF) RT5
(+12V) Vcc 1 5
(-12V) VGG
(LOGIC RETURN) Vss 2 6
3 7
(+5V) Vcc 4 8
J6
1 11 Vss (LOGIC RETURN)
2 12 Vcc (+5V)
ACK
3 13
IC 6
IC 5 4 14
IC 4
IC 3 5 15
IC 2
IC 1 6 16
IC 0
INTERBUS CONTROL
ID 7 7 17
ID 6
ID 5 8 18
ID 4
ID 3 9 19
ID 2
ID 1 10 20
ID 0
INTERBUS DATA

NOTES:

5 THIS BUS LINE IS INTERCONNECTED ON J21, J22, J23 & J29 BUT HAS NO USE ON 8502A APPLICATIONS IN THESE LOCATIONS. FUNCTION INDICATED IS FOR J11 ONLY. NO INTERCONNECT EXISTS BETWEEN J11, PIN 23 & OTHER CONNECTORS ON GUARDED BUS

6 FUNCTION WILL VARY DEPENDING UPON BUS INTERCONNECTION INSTALLED IN UNIT.

FUNCTION	ISOLATOR (OPTION-01)	BUS INTERCONNECT (MIS-1081)
VSS	0	-20 V
VDD	+12V	-8V
VGG	-12 V	-32 V
VCC	+5V	-15 V

7 CONNECTION FOR PARALLEL REAR INPUT-017 SEE 8500A-1314

8 CONNECTION FOR SWITCED FRONT/REAR INPUT-016 SEE 8502A-1011

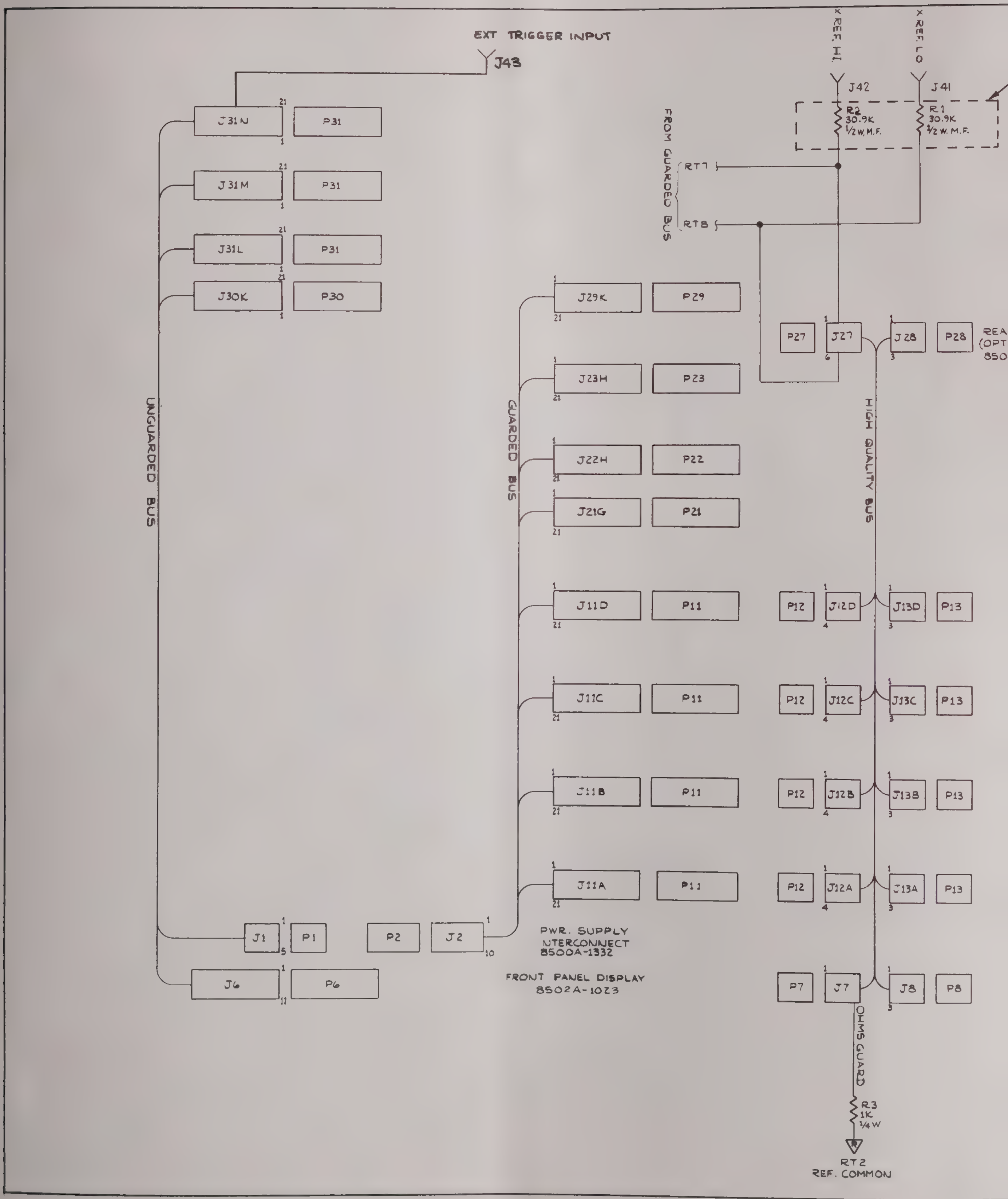
9 CONNECTION FOR FRONT PANEL INPUT SEE 8502A-16.

10 USED ON -081 ONLY.

11 RESISTORS R1 & R2 REMOVED ON -16 OPTION.

8502A-1001

Figure 8-1. A2 Motherboard PCB Assembly (cont)


EXT TRIGGER INPUT
J43
X REF. HI.
X REF. LO
J42
J41
R2
30.9K
1/2 W, M.F.
R1
30.9K
1/2 W. M.F.
FROM GUARDED BUS
RT7
RT8
J31N
P31
J31M
P31
J31L
P31
J30K
P30
J29K
P29
J23H
P23
J22H
P22
J21G
P21
P27
J27
J28
P28
REA
(OPT
850
UNGUARDED BUS
GUARDED BUS
HIGH QUALITY BUS
J11D
P11
P12
J12D
J13D
P13
J11C
P11
P12
J12C
J13C
P13
J11B
P11
P12
J12B
J13B
P13
J11A
P11
P12
J12A
J13A
P13
J1
P1
P2
J2
PWR. SUPPLY
NTERCONNECT
8500A-1332
J6
P6
FRONT PANEL DISPLAY
8502A-1023
P7
J7
J8
P8
OHMS GUARD
R3
1K
1/4 W
RT2
REF. COMMON
1
5
10
11
21
3
4
6

>

7

MODULE INSTALLATION LOCATIONS			
MODULE DESCRIPTION	SCHEMATIC DWG NO.	PREFERRED SLOT	PERMISSABLE SLOTS
D.C. SIGNAL COND.	M.I.S.-1100	A	A B C D
AC. CONV. (OPTION -01)	M.I.S.-1101	B	A B C D
R.M.S. CONV. (OPTION -091)	M.I.S.-1102	B	A B C D
CURRENT SHUNT (OPTION -03)	M.I.S.-1104	C	A B C D
OHMS CONV. (OPTION -02)	M.I.S.-1110	D	A B C D
FILTER	M.I.S.-1130	G	G
A/D CONV.	M.I.S.-1140 M.I.S.-1141	H	H
BUS INTERCONNECT	M.I.S.-1081	K	K
ISOLATOR (OPTION -081)	8502A-1181	K	K
CONTROLLER	8502A-1185	N (WHEN I/O NOT INSTALLED)	L M N
CALIBRATION MEMORY (OPTION -04)	M.I.S.-1160	M	L M N
BIT SERIAL (OPTION -06)	M.I.S.-1170	N	L M K
PARALLEL INTERFACE (OPTION -07)	M.I.S.-1171	N	L M N
IEEE INTERFACE (OPTION -05)	M.I.S.-1072 M.I.S.-1172	N	L M N

OTES

REMOVE FOR -16 OPTION

SERVICE / FIELD AIDS - LOCATIONS			
DESCRIPTION	SCHEMATIC DWG. NO	PREFERRED SLOT	PERMISSABLE SLOTS
STATIC CONTROLLER M.I.S.-7190K	M.I.S.-1190	L M N	A B C D L M N
TEST MODULE M.I.S.-7191K	M.I.S.-1191	A B C D	A B C D L M N
EXTENDER M.I.S.-7011K		NONE	ANY
BUS INTERCONNECT & MONITOR M.I.S.-7013K		K	ANY

8502A-1301
Sht 1 of 2

Figure 8-2. Interconnect Diagram Mother Assembly

FUNCTION TABLE		
CONNECTOR	PIN NO.	FUNCTION
J1 (Unguarded Bus)	1	+12V Vdd
	2	Vss(Logic Return)
	3	NC
	4	+15V Vcc
	5	RT5 (Line Freq. Ref.)
	6	-12V Vgg
	7	Vss(Logic Return)
	8	+5V Vcc
J2 (Guarded Bus)	1	-15V Vcc(Logic Supply)
	2	-20V Vss(Logic Return)
	3	AR(Analog Return)
	4	-15V VA2
	5	-30V VA4
	6	NC
	7	NC
	8	NC
	9	Guard
	10	-15V Vcc(Logic Supply)
	11	-20V Vss(Logic Return)
	12	AR(Analog Return)
	13	+15V VA1
	14	+30V VA3
	15	NC
	16	NC
	17	NC
	18	Guard
J6 (unguarded Bus)	1	Vss (Logic Return)
	2	ACK (Acknowledge)
	3	+5V Vcc
	4	IC5 (Interbus Control)
	5	IC3 (Interbus Control)
	6	IC1 (Interbus Control)
	7	ID7 (Interbus Data)
	8	ID5 (Interbus Data)
	9	ID3 (Interbus Data)
	10	ID1 (Interbus Data)
	11	Vss (Logic Return)
	12	+5V Vcc
	13	IC6 (Interbus Control)
	14	IC4 (Interbus Control)
	15	IC2 (Interbus Control)
	16	IC0 (Interbus Control)
	17	ID6 (Interbus Data)
	18	ID4 (Interbus Data)
	19	ID2 (Interbus Data)
	20	ID0 (Interbus Data)
J7 (High Quality Bus)	1	Guard
	2	Input Lo
	3	Source Lo
	4	Ohm's Guard
	5	Guard
	6	Input Lo
	7	Source Lo
	8	Ohm's Guard
J8 (High Quality Bus)	1	Source Hi
	2	Input Hi
	3	Source Hi
	4	Input Hi
J11A J11B J11C J11D (Guarded Bus)	1	Guard
	2	RT0 (Ohm's Guard)
	3	RT2 (Ref. Common)
	4	RT4 (Ref. -7V. A/D to Ohm's Conv.)
	5	RT6 (DC. AMP., AC. Avg., & AC. RMS. Output. +A/F. input)
	6	RT8 (X. Ref. Lo.)
	7	-30V VA4
	8	-15V VA2
	9	AR (Analog Return)
	10	$\overline{\text{INT}}$ (Interupt not)
	11	-20V Vss (Logic Return)
	12	-15V Vcc (Logic Supply)
	13	IC6 (Interbus Control)
	14	IC4 (Interbus Control)
	15	IC2 (Interbus Control)
	16	IC0 (Interbus Control)

FUNCTION TABLE		
CONNECTOR	PIN NO.	FUNCTION
J11A J11B J11C J11D (Guarded Bus)	17	ID6(Interbus Data)
	18	ID4(Interbus Data)
	19	ID2(Interbus Data)
	20	ID0(Interbus Data)
	21	Guard
	22	RT0(Ohms Guard)
	23	RT1(Ohms & Current Output HI. +DC. AMP., AC. Avg.,& AC. RMS. Input Hi.)
	24	RT3(AC. Avg.,& RMS, Input Lo) +(Current Output Lo.)
	25	RT5(A/D Input & A/F Output)
	26	RT7(X.Ref. HI)
	27	+30V VA3
	28	+15V VA1
	29	INA(Interupt Acknowledge)
	30	AR(Analog Return)
	31	-20V Vss(Logic Return)
	32	ACK(Acknowledge)
	33	-15V Vcc(Logic Supply)
	34	IC5(Interbus Control)
	35	IC3 (Interbus Control)
	36	IC1 (Interbus Control)
	37	ID7 (Interbus Data)
	38	ID5 (Interbus Data)
	39	ID3 (Interbus Data)
	40	ID1 (Interbus Data)
J12A J12B J12C J12D (High Quality Bus)	1	Input Lo
	2	Source Lo
	3	Ohms Guard
	4	Input Lo
	5	Source Lo
	6	Ohms Guard
J13A J13B J13C J13D (High Quality Bus)	1	Source Hi
	2	Input Hi
	3	Source Hi
	4	Input Hi
J27 (High Quality Bus)	1	Guard
	2	X Ref. Hi
	3	Input Lo
	4	Source Lo
	5	Ohms Guard
	6	Guard
	7	X Ref. Lo
	8	Input Lo
	9	Source Lo
	10	Ohms Guard
J28 (High Quality Bus)	1	Source Hi
	2	Input Hi
	3	Source Hi
	4	Input Hi
J21G J22H J23H J29K (Guarded Bus)	1	Guard
	2	RT0(Ohms Guard)
	3	RT2(Ref. Common)
	4	RT4(Ref.-7V. A/D to Ω Conv.)
	5	RT6(DC. AMP., AC. Avg.,& AC.RMS. Output. +A/F. input)
	6	RT8(X.Ref. Lo)
	7	-30V VA4
	8	-15V VA2
	9	AR(Analog Return)
	10	$\overline{\text{INT}}$(Interupt not)
	11	-20V Vss(Logic Return)
	12	-15V Vcc(Logic Supply)
	13	IC6(Interbus Control)
	14	IC4(Interbus Control)
	15	IC2(Interbus Control)
	16	IC0(Interbus Control)
	17	ID6(Interbus Data)
	18	ID4(Interbus Data)
	19	ID2(Interbus Data)
	20	ID0(Interbus Data)

CONNECTOR	PIN NO.
J21G J22H J23H J29K (Guarded Bus)	21
	22
	23
	24
	25
	26
	27
	28
	29
	30
	31
	32
	33
	34
	35
	36
	37
	38
	39
	40
J30K J31N J31M J31L (Unguarded Bus)	1
	2
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12
	13
	14
	15
	16
	17
	18
	19
	20
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	22
	23
	24
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7 \

MODULE INSTALLATION LOCATIONS

MODULE DESCRIPTION	SCHEMATIC DWG NO.	PREFERRED SLOT	PERMISSABLE SLOTS
D.C. SIGNAL COND.	M.I.S.-1100	A	A B C D
AC. CONV. (OPTION -01)	M.I.S.-1101	B	A B C D
R.M.S. CONV. (OPTION -091)	M.I.S.-1102	[illegible]	A B C D
CURRENT SHUNT (OPTION -03)	M.I.S.-1104	C	A B C D
OHMS CONV. (OPTION -02)	M.I.S.-1110	D	A B C D
FILTER	M.I.S.-1130	G	G
A/D CONV.	M.I.S.-1140 M.I.S.-1141	H	H
BUS INTERCONNECT	M I.S.-1081	K	K
ISOLATOR (OPTION -08)	8502A-1181	K	K
CONTROLLER	8502A-1185	N (WHEN I/O NOT INSTALLED)	L M N
CALIBRATION MEMORY (OPTION -04)	M.I.S.-1160	M	L M N
BIT SERIAL (OPTION -06)	M.I.S.-1170	N	L M N
PARALLEL INTERFACE (OPTION -07)	M.I.S.-1171	N	L M N
IEEE INTERFACE (OPTION -05)	M.I.S.-1072 M.I.S.-1172	N	L M N

OTES

▷ REMOVE FOR -16 OPTION

SERVICE / FIELD AIDS - LOCATIONS

DESCRIPTION	SCHEMATIC DWG. NO	PREFERRED SLOT	PERMISSABLE SLOTS
STATIC CONTROLLER M.I.S.-7190K	M.I.S.-1190	L M N	A B C D L M N
TEST MODULE M.I.S.-7191K	M.I.S.-1191	A B C D	A B C D L M N
EXTENDER M.I.S.-7011K		NONE	ANY
BUS INTERCONNECT & MONITOR M.I.S.-7013K		K	ANY

8502A-1301
Sht 1 of 2

Figure 8-2. Interconnect Diagram Mother Assembly

FUNCTION TABLE		
CONNECTOR	PIN NO.	FUNCTION
J1 (Unguarded Bus)	1	+12V Vdd
	2	Vss(Logic Return)
	3	NC
	4	+15V Vcc
	5	RT5 (Line Freq. Ref.)
	6	-12V Vgg
	7	Vss(Logic Return)
	8	+5V Vcc
J2 (Guarded Bus)	1	-15V Vcc(Logic Supply)
	2	-20V Vss(Logic Return)
	3	AR(Analog Return)
	4	-15V VA2
	5	-30V VA4
	6	NC
	7	NC
	8	NC
	9	Guard
	10	-15V Vcc(Logic Supply)
	11	-20V Vss(Logic Return)
	12	AR(Analog Return)
	13	+15V VA1
	14	+30V VA3
	15	NC
	16	NC
	17	NC
	18	Guard
J6 (unguarded Bus)	1	Vss (Logic Return)
	2	ACK (Acknowledge)
	3	+5V Vcc
	4	IC5 (Interbus Control)
	5	IC3 (Interbus Control)
	6	IC1 (Interbus Control)
	7	ID7 (Interbus Data)
	8	ID5 (Interbus Data)
	9	ID3 (Interbus Data)
	10	ID1 (Interbus Data)
	11	Vss (Logic Return)
	12	+5V Vcc
	13	IC6 (Interbus Control)
	14	IC4 (Interbus Control)
	15	IC2 (Interbus Control)
	16	IC0 (Interbus Control)
	17	ID6 (Interbus Data)
	18	ID4 (Interbus Data)
	19	ID2 (Interbus Data)
	20	ID0 (Interbus Data)
J7 (High Quality Bus)	1	Guard
	2	Input Lo
	3	Source Lo
	4	Ohm's Guard
	5	Guard
	6	Input Lo
	7	Source Lo
	8	Ohm's Guard
J8 (High Quality Bus)	1	Source Hi
	2	Input Hi
	3	Source Hi
	4	Input Hi
J11A J11B J11C J11D (Guarded Bus)	1	Guard
	2	RT0 (Ohm's Guard)
	3	RT2 (Ref. Common)
	4	RT4 (Ref. -7V. A/D to Ohm's Conv.)
	5	RT6 (DC. AMP., AC. Avg., & AC. RMS. Output. +A/F. Input)
	6	RT8 (X. Ref. Lo.)
	7	-30V VA4
	8	-15V VA2
	9	AR (Analog Return)
	10	$\overline{\text{INT}}$ (Interupt not)
	11	-20V Vss (Logic Return)
	12	-15V Vcc (Logic Supply)
	13	IC6 (Interbus Control)
	14	IC4 (Interbus Control)
	15	IC2 (Interbus Control)
	16	IC0 (Interbus Control)

FUNCTION TABLE		
CONNECTOR	PIN NO.	FUNCTION
J11A J11B J11C J11D (Guarded Bus)	17	ID6(Interbus Data)
	18	ID4(Interbus Data)
	19	ID2(Interbus Data)
	20	ID0(Interbus Data)
	21	Guard
	22	RT0(Ohms Guard)
	23	RT1(Ohms & Current Output HI. +DC. AMP., AC. Avg.,& AC. RMS. Input HI.)
	24	RT3(AC. Avg.,& RMS, Input Lo) +(Current Output Lo.)
	25	RT5(A/D Input & A/F Output)
	26	RT7(X.Ref. HI)
	27	+30V VA3
	28	+15V VA1
	29	INA(Interupt Acknowledge)
	30	AR(Analog Return)
	31	-20V Vss(Logic Return)
	32	ACK(Acknowledge)
	33	-15V Vcc(Logic Supply)
	34	IC5(Interbus Control)
	35	IC3(Interbus Control)
	36	IC1(Interbus Control)
	37	ID7(Interbus Data)
	38	ID5(Interbus Data)
	39	ID3(Interbus Data)
	40	ID1(Interbus Data)
J12A J12B J12C J12D (High Quality Bus)	1	Input Lo
	2	Source Lo
	3	Ohms Guard
	4	Input Lo
	5	Source Lo
	6	Ohms Guard
J13A J13B J13C J13D (High Quality Bus)	1	Source HI
	2	Input HI
	3	Source HI
	4	Input HI
J27 (High Quality Bus)	1	Guard
	2	X Ref. HI
	3	Input Lo
	4	Source Lo
	5	Ohms Guard
	6	Guard
	7	X Ref. Lo
	8	Input Lo
	9	Source Lo
	10	Ohms Guard
J28 (High Quality Bus)	1	Source HI
	2	Input HI
	3	Source HI
	4	Input HI
J21G J22H J23H J29K (Guarded Bus)	1	Guard
	2	RT0(Ohms Guard)
	3	RT2(Ref. Common)
	4	RT4(Ref.-7V. A/D to Ω Conv.)
	5	RT6(DC. AMP., AC. Avg., & AC.RMS. Output. +A/F. Input)
	6	RT8(X.Ref. Lo)
	7	-30V VA4
	8	-15V VA2
	9	AR(Analog Return)
	10	$\overline{\text{INT}}$(Interupt not)
	11	-20V Vss(Logic Return)
	12	-15V Vcc(Logic Supply)
	13	IC6(Interbus Control)
	14	IC4(Interbus Control)
	15	IC2(Interbus Control)
	16	IC0(Interbus Control)
	17	ID6(Interbus Data)
	18	ID4(Interbus Data)
	19	ID2(Interbus Data)
	20	ID0(Interbus Data)

FUNCTION T		
CONNECTOR	PIN NO.	
J21G J22H J23H J29K (Guarded Bus)	21	Guard
	22	RT0(Ohms
	23	11
	24	RT3(AC. A + Current
	25	RT5(A/D I
	26	RT7(X.Ref
	27	+30V VA3
	28	+15V VA1
	29	INA(Inter
	30	AR(Analog
	31	-20V Vss(
	32	ACK(Ackno
	33	-15V Vcc(
	34	IC5(Interb
	35	IC3(Interb
	36	IC1(Interb
	37	ID7(Interb
	38	ID5(Interb
	39	ID3(Interb
	40	ID1(Interb
J30K J31N J31M J31L (Unguarded Bus)	1	Guard(Log
	2	RT0(Real
	3	RT2(Real
	4	RT4(Real
	5	RT6(Real
	6	Vgg
	7	NC
	8	NC
	9	NC
	10	$\overline{\text{INT}}$(Inter
	11	Vss(Logic
	12	Vcc
	13	IC6(Interb
	14	IC4(Interb
	15	IC2(Interb
	16	IC0(Interb
	17	ID6(Interb
	18	ID4(Interb
	19	ID2(Interb
	20	ID0(Interb
	21	Guard(Log
	22	RT0(Real
	23	RT1(Real
	24	RT3(Real
	25	RT5(Line
	26	Vdd
	27	NC TRIG
	28	NC TRIG
	29	INA(Inter
	30	NC
	31	Vss(Logic
	32	ACK(Ackno
	33	Vcc
	34	IC5(Interb
	35	IC3(Interb
	36	IC1(Interb
	37	ID7(Interb
	38	ID5(Interb
	39	ID3(Interb
	40	ID1(Interb

LE

FUNCTION
ard)
.,& RMS. Input Lo utput Lo.)
ut & A/F.Output)
HI)
t Acknowledge)
eturn)
gic Return)
edge)
gic Supply)
s Control)
s Control)
s Control)
s Data)
s Data)
s Data)
s Data)
Common)
me 0)
me 2)
me 4)
me 6)
12
pt not)
eturn) 12
2
s Control)
s Control)
s Control)
s Control)
s Data)
s Data)
s Data)
s Data)
Common)
me 0)
me 1)
me 3)
eq. Ref)
12
ER INPUT HI
SER INPUT LO
pt Acknowledge)
eturn) 12
edge)
12
s Control)
s Control)
s Control)
s Data)
s Data)
s Data)
s Data)

Notes:

11. This Bus line is not used for 8500A applications, but it is interconnected on J21G, J22H, J23H, & J29K. No connection is made with J11 Pin 23.

12. Functions will vary depending upon type of Bus Interconnection installed in unit.

Function	Isolator (option-081)	Bus Interconnect (MIS-1081)
Vss	0	-20V
Vdd	+12V	-8V
Vgg	-12V	-32V
Vcc	+5V	-15V

8502A-1301
Sht 2 of 2

Figure 8-2. Interconnect Diagram Mother Assembly (cont)

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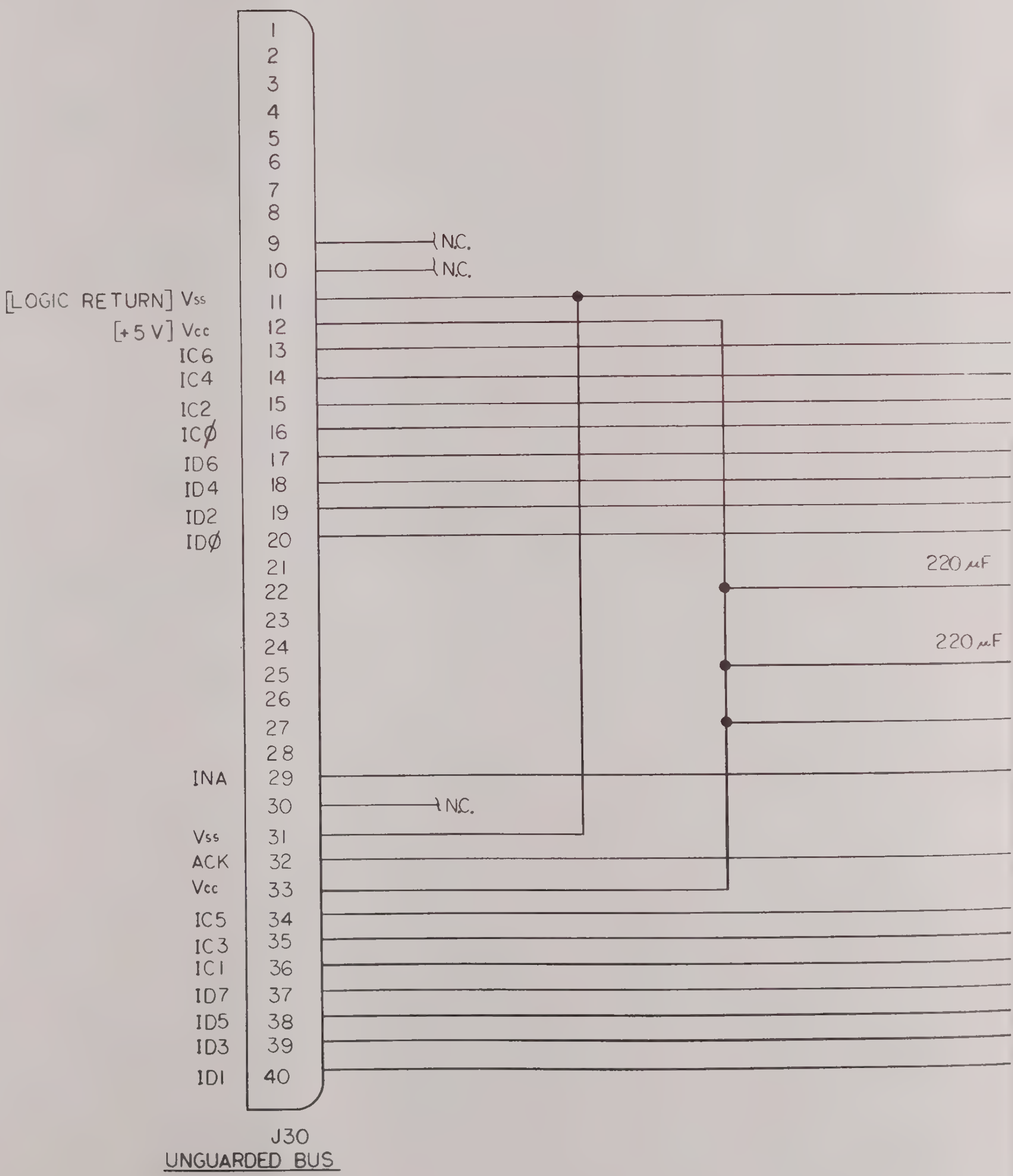

1
2
3
4
5
6
7
8
9
10
N.C.
N.C.
[LOGIC RETURN] Vss 11
[+5 V] Vcc 12
IC6 13
IC4 14
IC2 15
IC0 16
ID6 17
ID4 18
ID2 19
ID0 20
21
22
23
24
25
26
27
28
INA 29
30
N.C.
Vss 31
ACK 32
Vcc 33
IC5 34
IC3 35
IC1 36
ID7 37
ID5 38
ID3 39
ID1 40
220 µF
220 µF
J30
UNGUARDED BUS

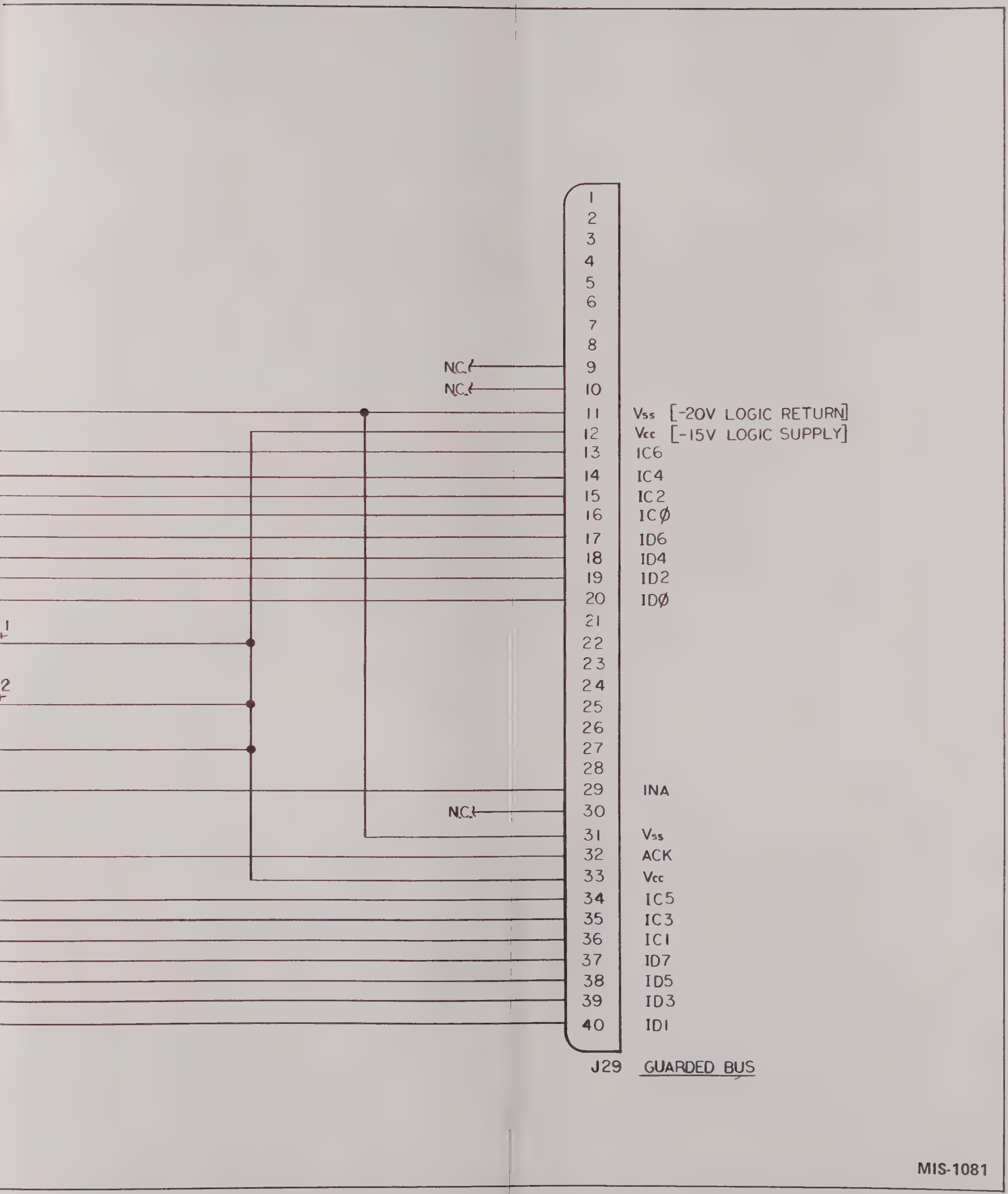
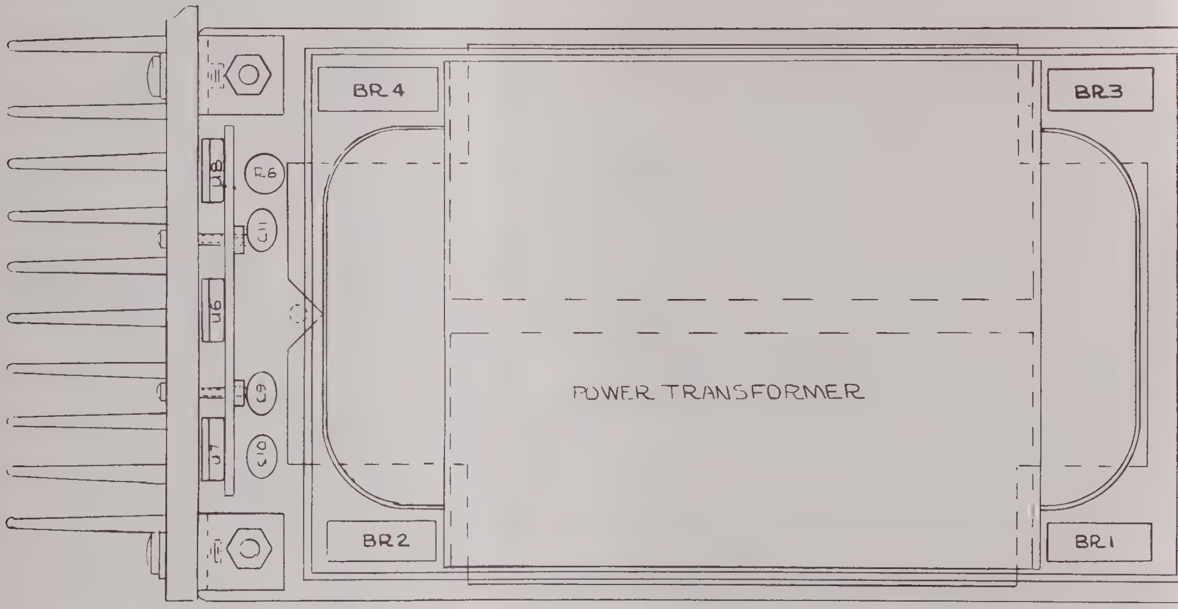
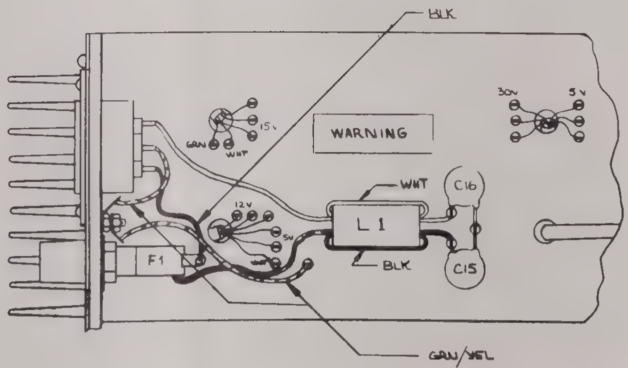
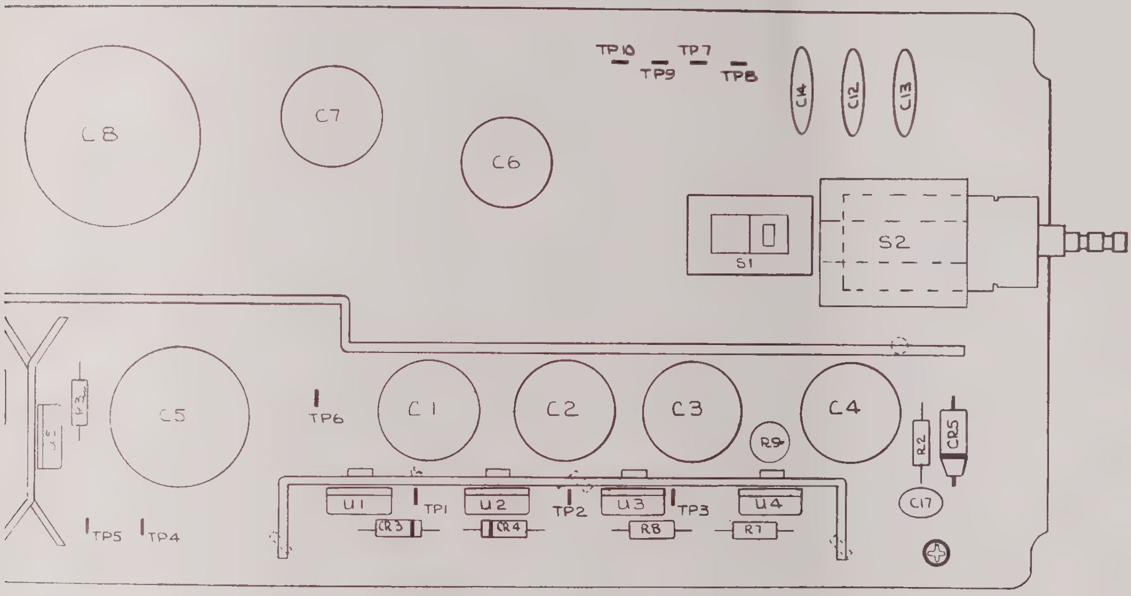

1
2
3
4
5
6
7
8
N.C. 9
N.C. 10
11 Vss [-20V LOGIC RETURN]
12 Vcc [-15V LOGIC SUPPLY]
13 IC6
14 IC4
15 IC2
16 IC0
17 ID6
18 ID4
19 ID2
20 ID0
21
22
23
24
25
26
27
28
29 INA
N.C. 30
31 Vss
32 ACK
33 Vcc
34 IC5
35 IC3
36 IC1
37 ID7
38 ID5
39 ID3
40 ID1
J29 GUARDED BUS
MIS-1081

Figure 8-3. Bus Interconnect


BR4
BR3
U8
R6
C11
U6
C9
U7
C10
POWER TRANSFORMER
BR2
BR1

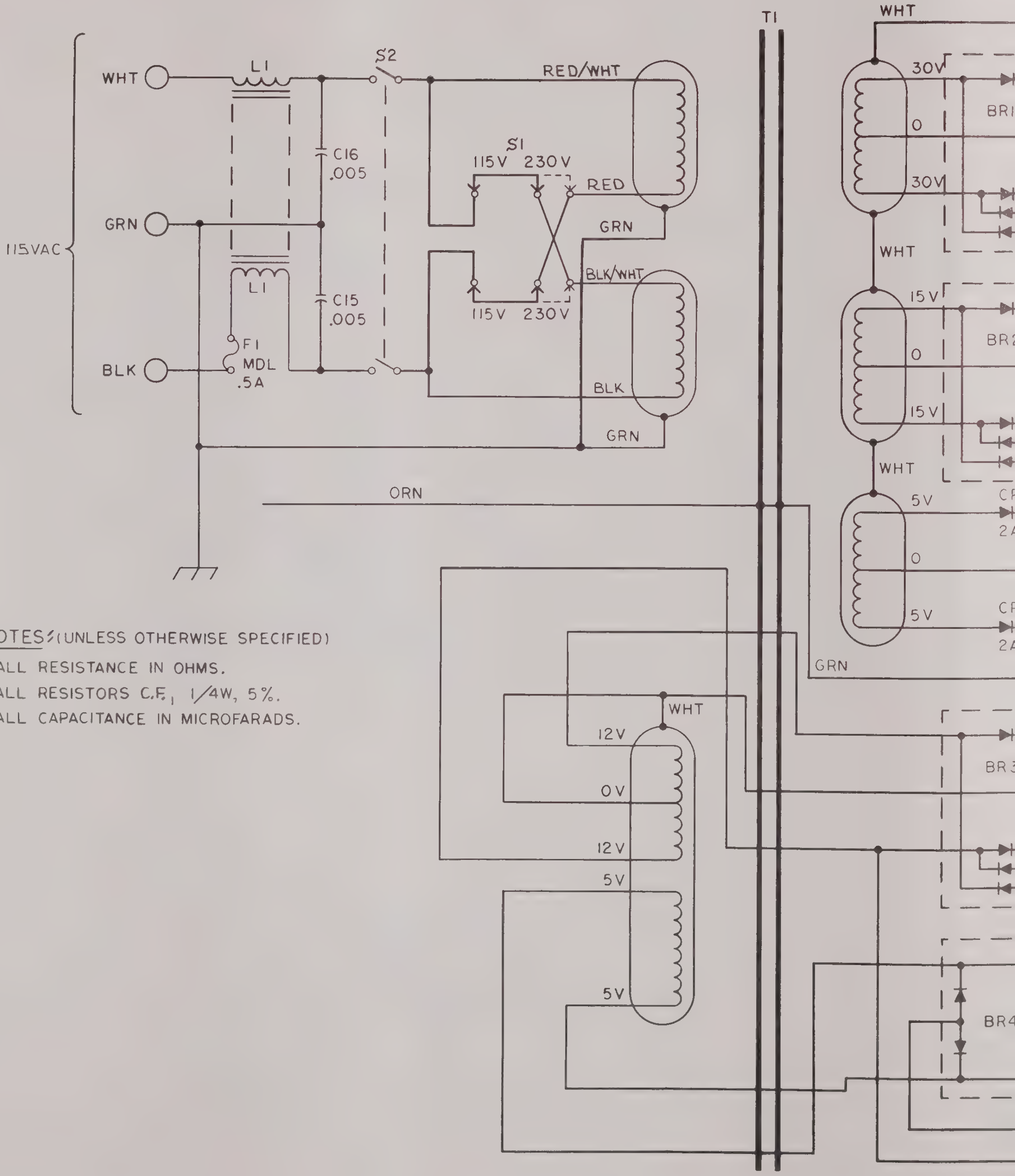

BLK
30V
5V
15V
GRN
WHT
WARNING
WHT
C16
12V
5V
L1
F1
BLK
C15
GRN/YEL

DETAIL OF CKT 1


TP10
TP9
TP7
TP8
C14
C12
C13
C8
C7
C6
S1
S2
R3
J3
C5
TP6
C1
C2
C3
C4
R9
R2
CR5
C17
U1
TP1
U2
TP2
U3
TP3
U4
CR3
CR4
R8
R7
TP5
TP4

8500A-1651

Figure 8-4. A4 Power Supply PCB Assembly—
Type 51


115VAC
WHT
GRN
BLK
L1
L1
C16
.005
C15
.005
F1
MDL
.5A
S2
S1
115V
230V
115V
230V
RED/WHT
RED
GRN
BLK/WHT
BLK
GRN
ORN
T1
WHT
30V
0
30V
BR1
WHT
15V
0
15V
BR2
WHT
5V
0
5V
GRN
WHT
12V
0V
12V
5V
5V
BR3
BR4

NOTES:(UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.F., 1/4W, 5%.
3. ALL CAPACITANCE IN MICROFARADS.

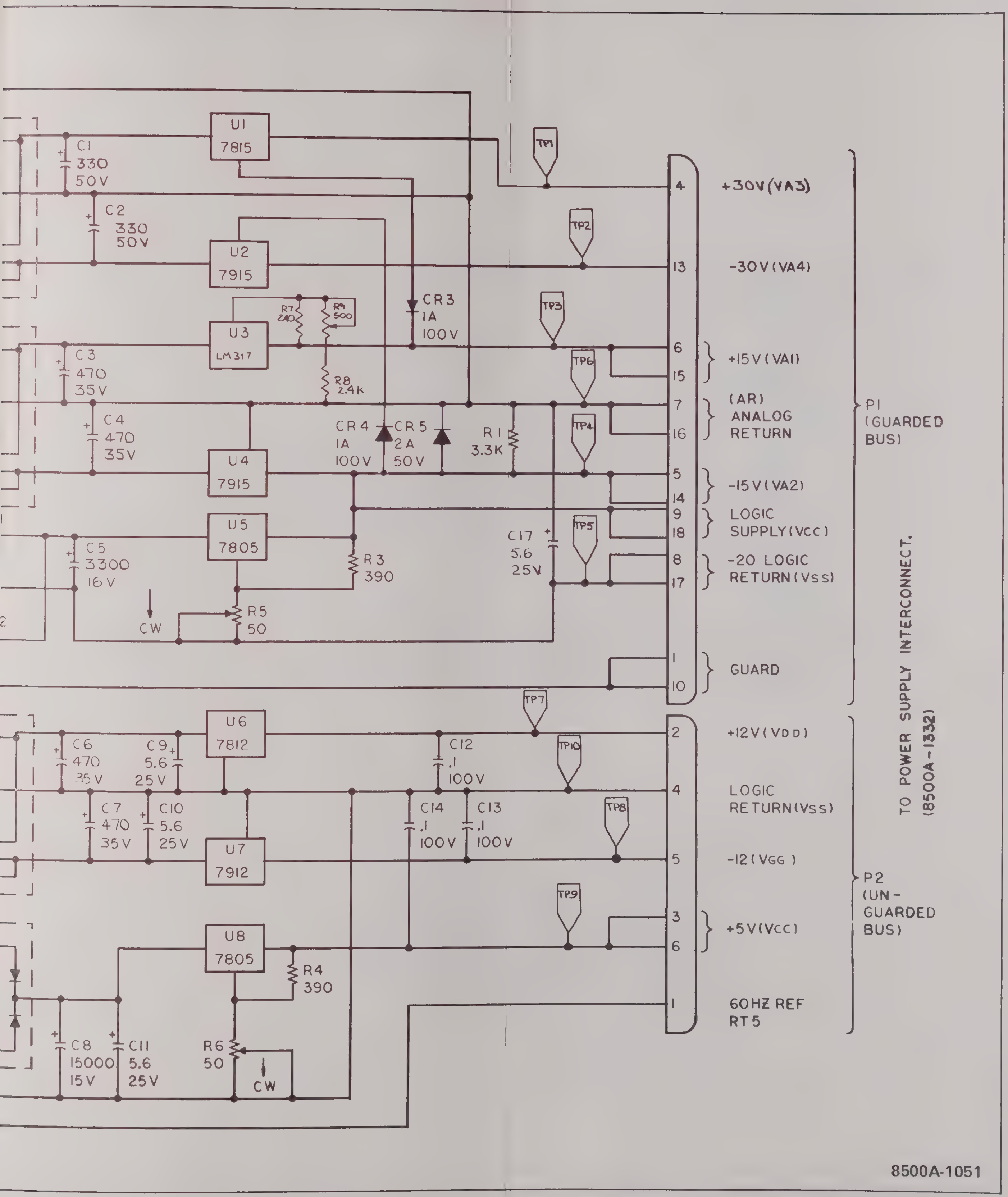
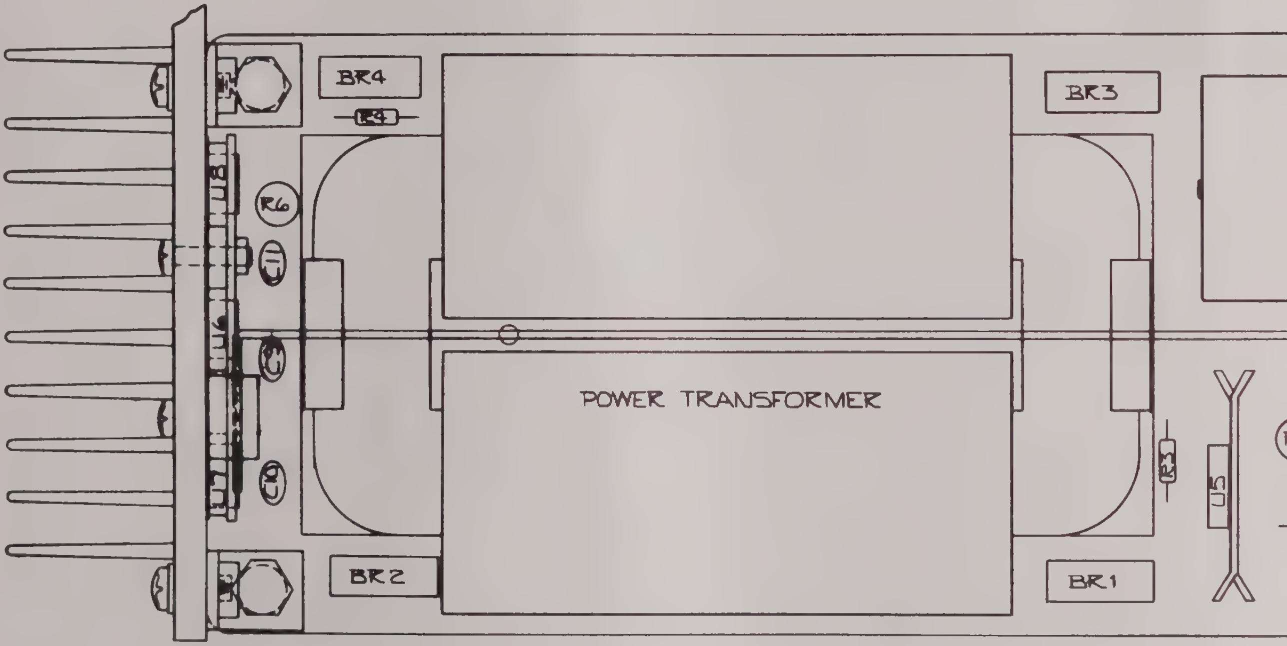
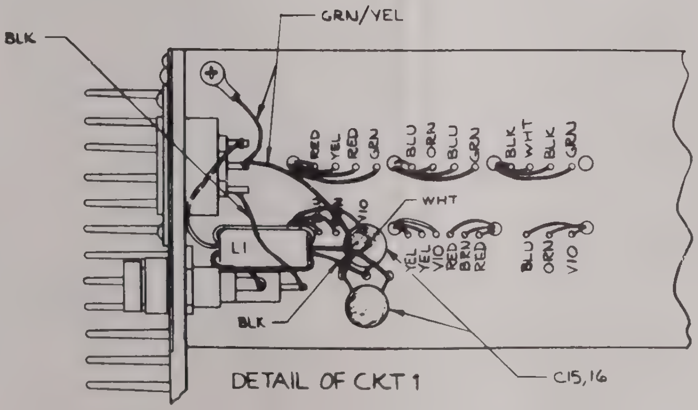
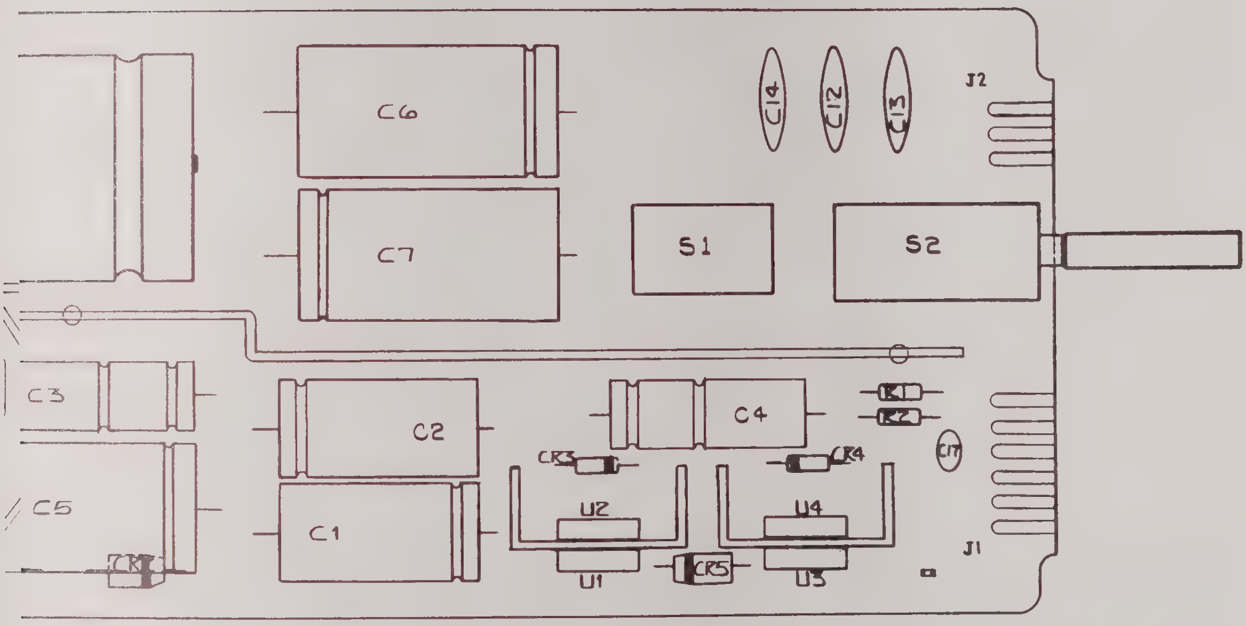

U1
7815
C1
330
50V
C2
330
50V
U2
7915
U3
LM317
R7
240
R9
500
R8
2.4K
CR3
1A
100V
C3
470
35V
C4
470
35V
U4
7915
CR4
1A
100V
CR5
2A
50V
R1
3.3K
U5
7805
C5
3300
16V
R3
390
C17
5.6
25V
R5
50
CW
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
TP10
4
13
6
15
7
16
5
14
9
18
8
17
1
10
+30V(VA3)
-30V(VA4)
+15V(VA1)
(AR)
ANALOG
RETURN
-15V(VA2)
LOGIC
SUPPLY(VCC)
-20 LOGIC
RETURN(Vss)
GUARD
P1
(GUARDED
BUS)
U6
7812
C6
470
35V
C9
5.6
25V
C7
470
35V
C10
5.6
25V
U7
7912
C12
.1
100V
C14
.1
100V
C13
.1
100V
U8
7805
R4
390
C8
15000
15V
C11
5.6
25V
R6
50
CW
2
4
5
3
6
1
+12V(VDD)
LOGIC
RETURN(Vss)
-12(VGG)
+5V(VCC)
60HZ REF
RT5
P2
(UN-
GUARDED
BUS)
TO POWER SUPPLY INTERCONNECT.
(8500A-1332)
2
8500A-1051

Figure 8-4. A4 Power Supply PCB Assembly — Type 51 (cont)


BR4
R4
BR3
R6
C11
C10
POWER TRANSFORMER
R3
U5
BR2
BR1

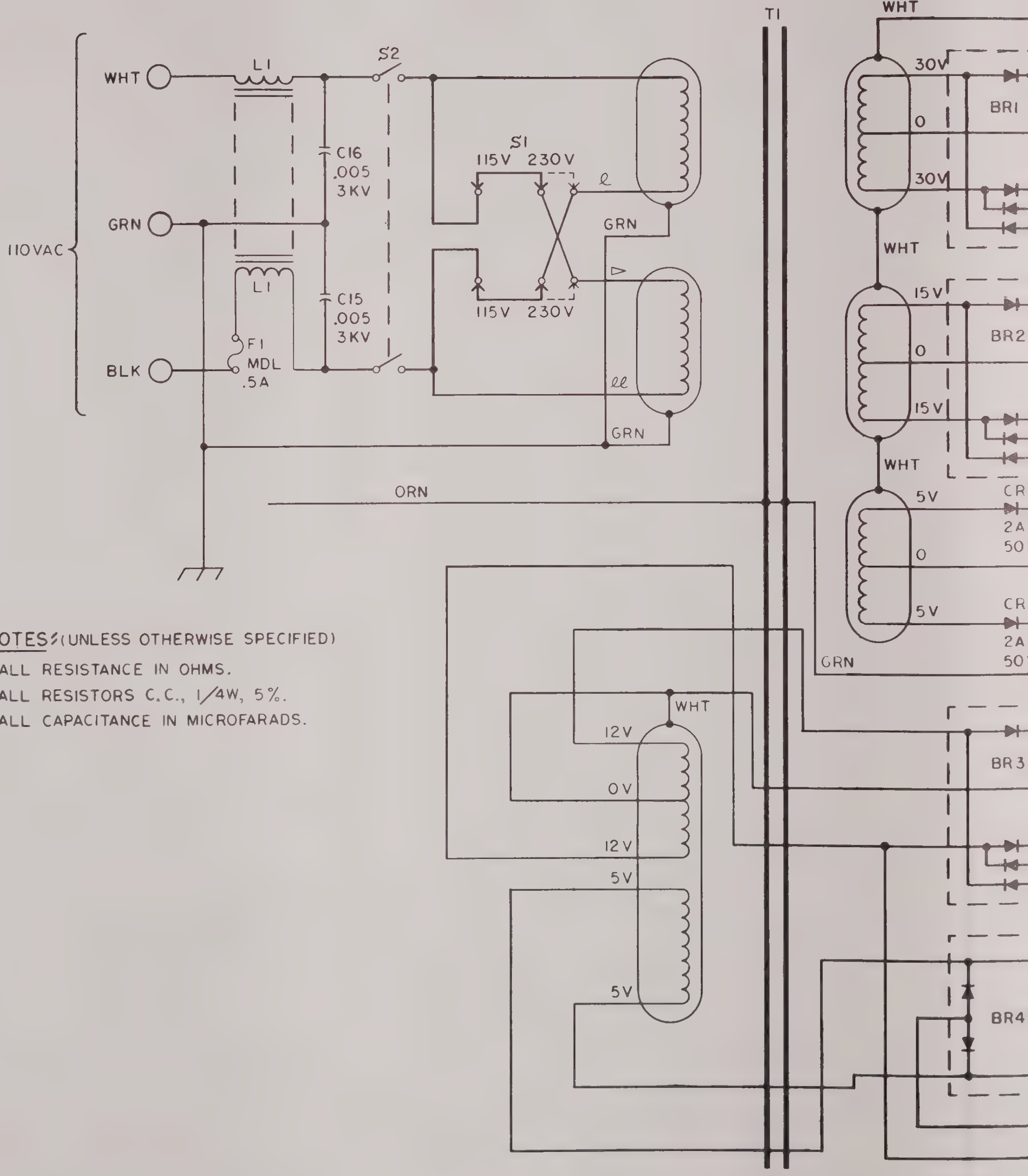

GRN/YEL
BLK
RED
YEL
RED
GRN
BLU
ORN
BLU
GRN
BLK
WHT
BLK
GRN
WHT
VIO
L1
YEL
YEL
VIO
RED
BRN
RED
BLU
ORN
VIO
BLK
C15,16

DETAIL OF CKT 1


C6
C14
C12
C13
J2
C7
S1
S2
C3
C2
C4
R1
R2
CR3
CR4
C17
C5
U2
U4
C1
J1
U1
CR5
U3

8500A-1641

Figure 8-5. A4 Power Supply PCB Assembly—
Type 41


110VAC
WHT
GRN
BLK
L1
L1
F1
MDL
.5A
C16
.005
3KV
C15
.005
3KV
S2
S1
115V
230V
115V
230V
ℓ
ℓℓ
GRN
GRN
ORN
T1
WHT
30V
0
30V
BR1
WHT
15V
0
15V
BR2
WHT
5V
0
5V
CR
2A
50
CR
2A
50
GRN
WHT
12V
0V
12V
5V
5V
BR3
BR4

NOTES:(UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.C., 1/4W, 5%.
3. ALL CAPACITANCE IN MICROFARADS.

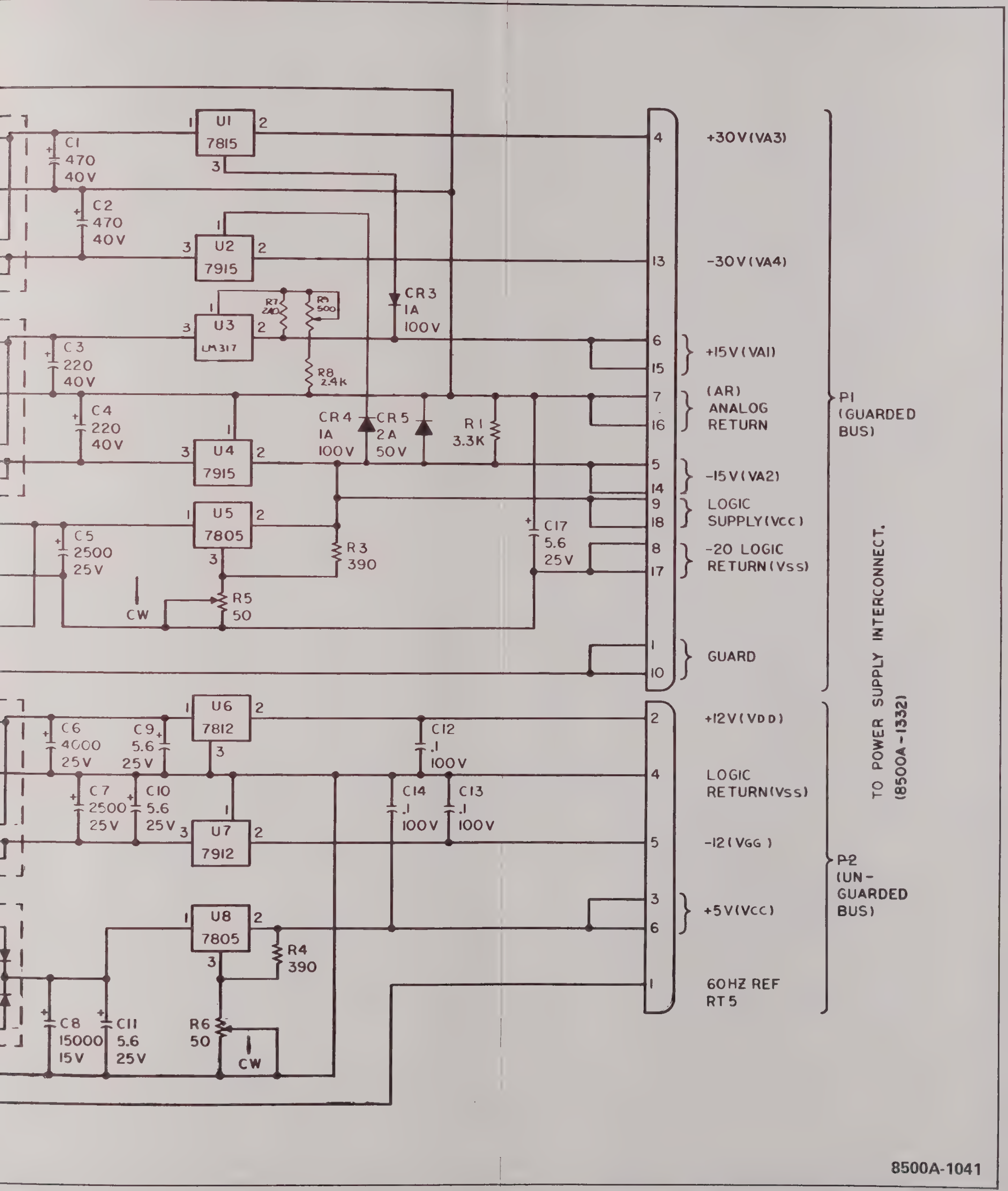

U1
7815
C1
470
40V
C2
470
40V
U2
7915
U3
LM317
R7
240
R9
500
R8
2.4K
CR3
1A
100V
C3
220
40V
C4
220
40V
U4
7915
CR4
1A
100V
CR5
2A
50V
R1
3.3K
U5
7805
C5
2500
25V
R3
390
C17
5.6
25V
R5
50
CW
4
+30V(VA3)
13
-30V(VA4)
6
15
+15V(VA1)
7
16
(AR)
ANALOG
RETURN
5
14
-15V(VA2)
9
18
LOGIC
SUPPLY(Vcc)
8
17
-20 LOGIC
RETURN(Vss)
1
10
GUARD
P1
(GUARDED
BUS)
U6
7812
C6
4000
25V
C9
5.6
25V
C12
.1
100V
C7
2500
25V
C10
5.6
25V
U7
7912
C14
.1
100V
C13
.1
100V
2
+12V(VDD)
4
LOGIC
RETURN(Vss)
5
-12(VGG)
3
6
+5V(VCC)
1
60HZ REF
RT5
P2
(UN-
GUARDED
BUS)
U8
7805
R4
390
C8
15000
15V
C11
5.6
25V
R6
50
CW
TO POWER SUPPLY INTERCONNECT.
(8500A-1332)
8500A-1041

Figure 8-5. A4 Power Supply PCB Assembly—Type 41 (cont)

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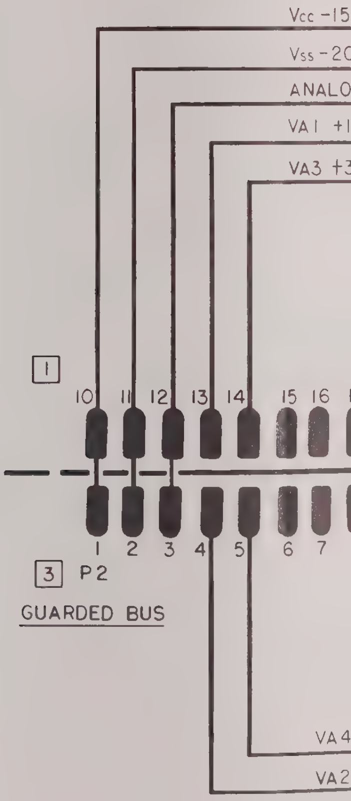
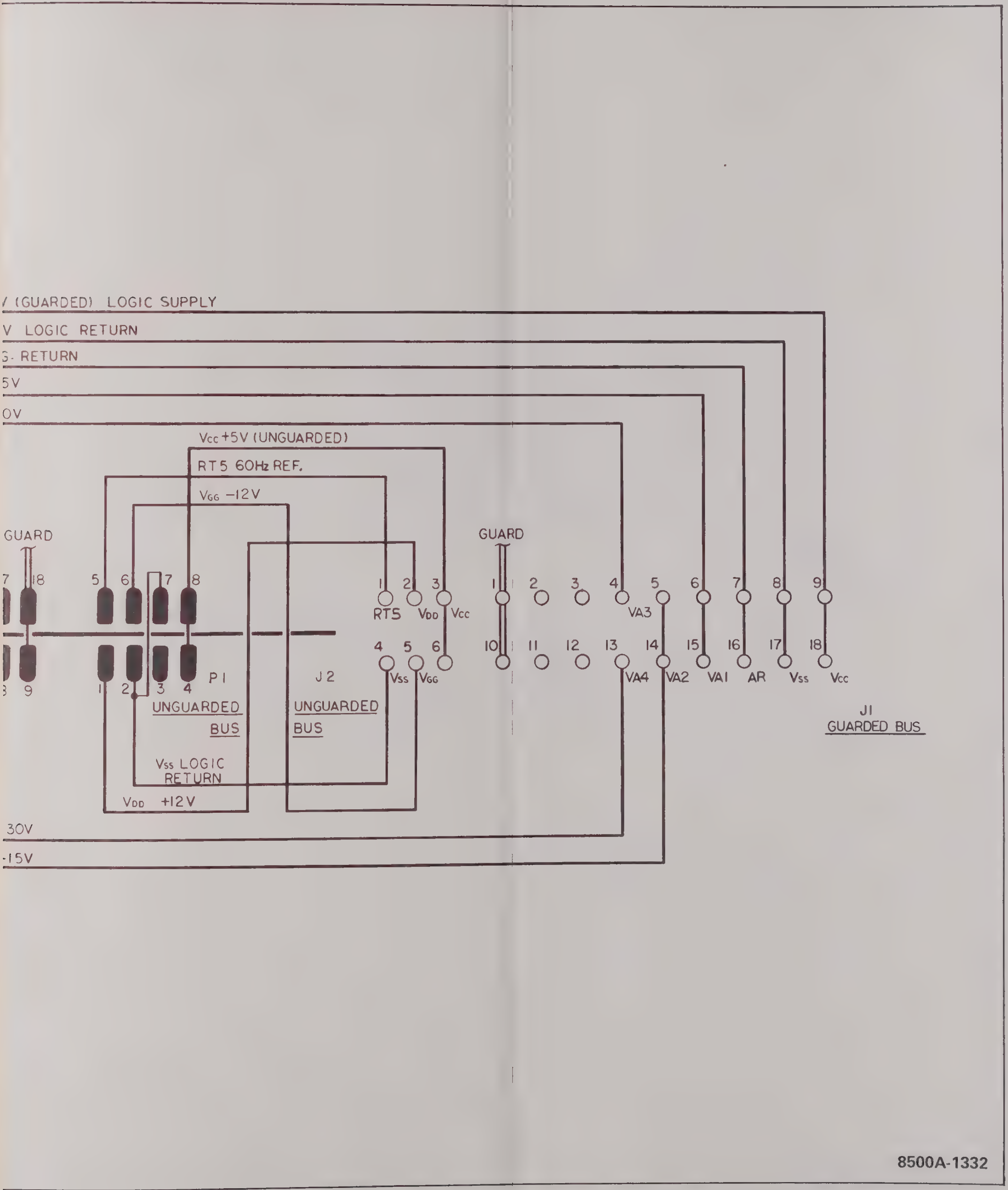
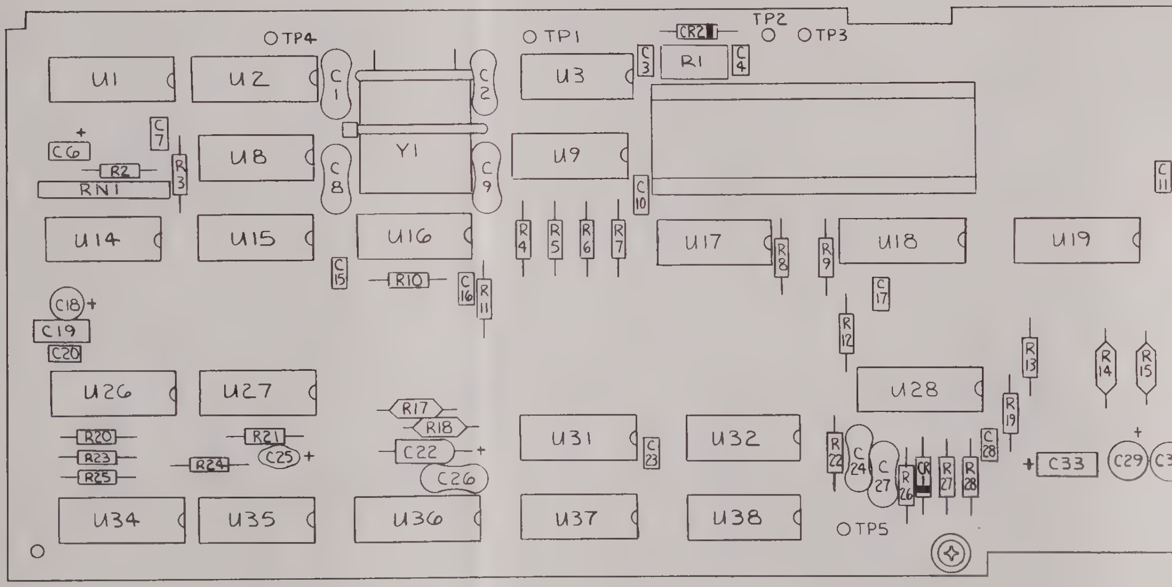

Vcc -15
Vss -20
ANALO
VA1 +1
VA3 +3
3 P2
GUARDED BUS
VA4
VA2



/ (GUARDED) LOGIC SUPPLY
V LOGIC RETURN
G- RETURN
5V
OV
Vcc +5V (UNGUARDED)
RT5 60Hz REF.
VGG −12V
GUARD
7
18
5
6
7
8
3
9
1
2
3
4
P1
UNGUARDED
BUS
J2
UNGUARDED
BUS
Vss LOGIC
RETURN
VDD +12V
1
2
3
RT5
VDD
Vcc
4
5
6
Vss
VGG
GUARD
1
2
3
4
5
6
7
8
9
VA3
10
11
12
13
14
15
16
17
18
VA4
VA2
VA1
AR
Vss
Vcc
J1
GUARDED BUS
30V
-15V
8500A-1332

Figure 8-6. A5 Power Supply Interconnect


TP4
TP1
CR2
TP2
TP3
U1
U2
C1
C2
U3
C3
R1
C4
C7
C6
U8
Y1
C8
C9
U9
R2
R3
RN1
C10
C11
U14
U15
U16
R4
R5
R6
R7
U17
R8
R9
U18
U19
C15
R10
C16
R11
C17
C18
C19
C20
R12
R13
R14
R15
U26
U27
U28
R17
R18
R19
R20
R21
C22
U31
C23
U32
R22
C24
C27
CR1
C28
C33
C29
R23
R25
R24
C25
C26
R26
R27
R28
U34
U35
U36
U37
U38
TP5

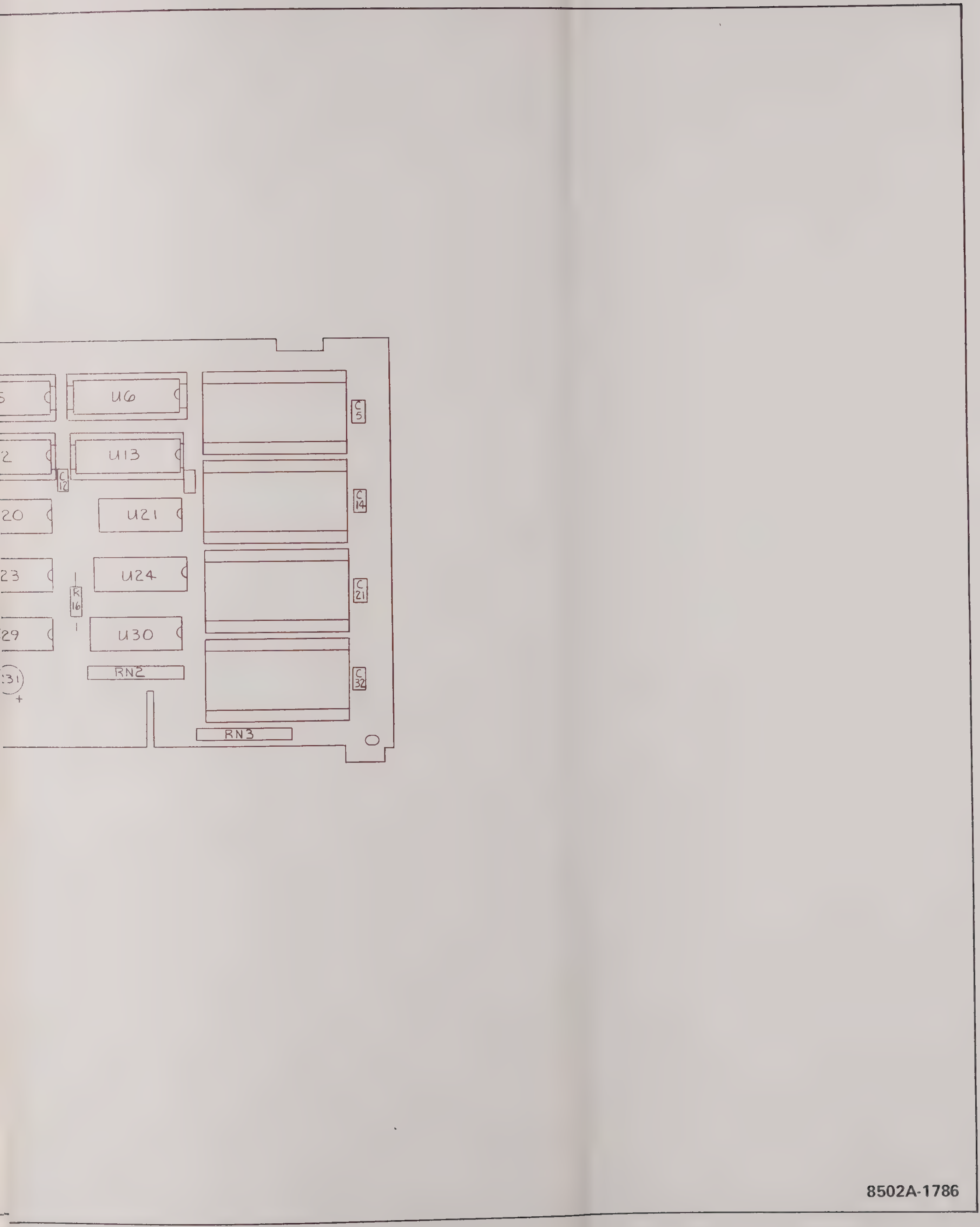
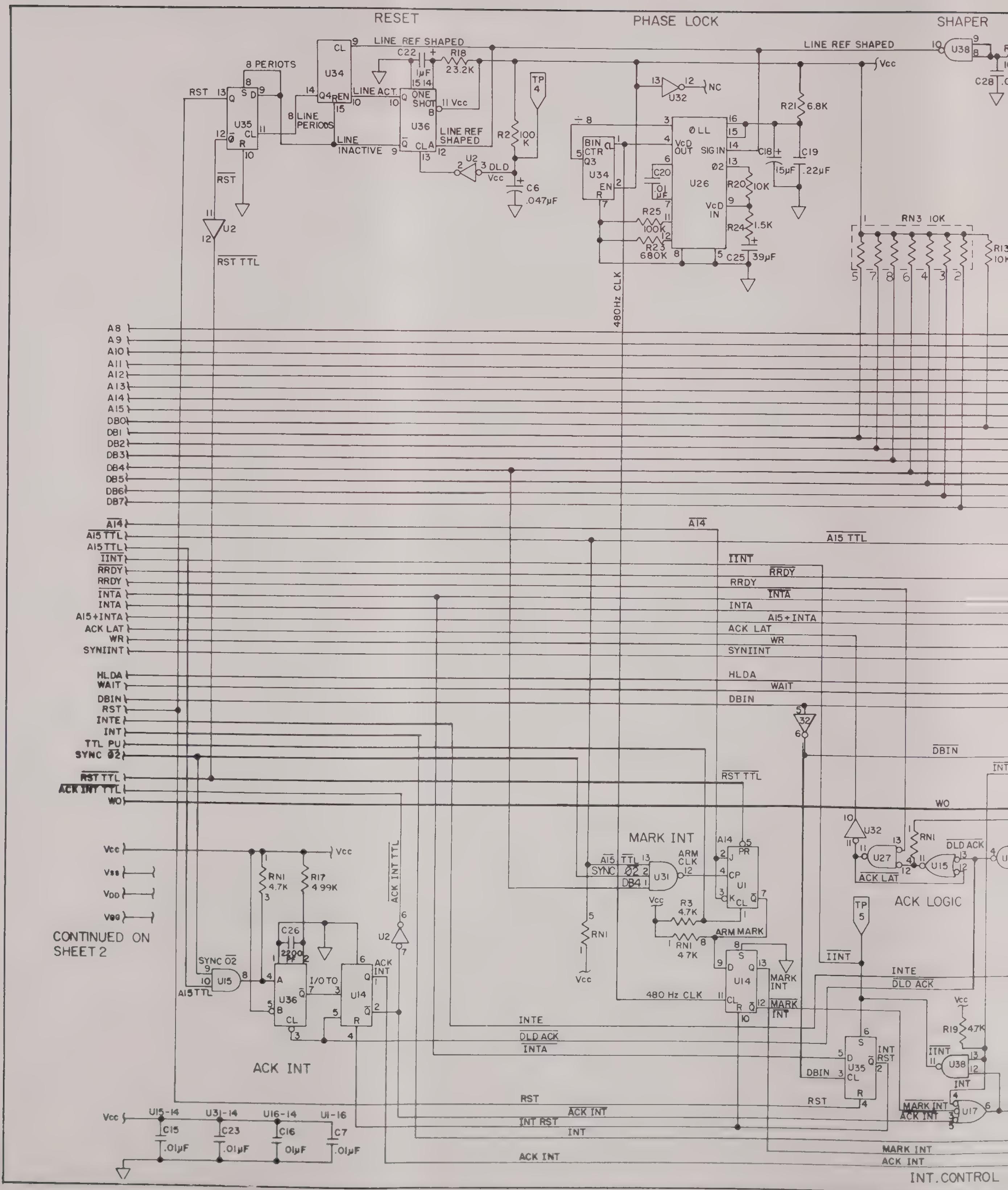
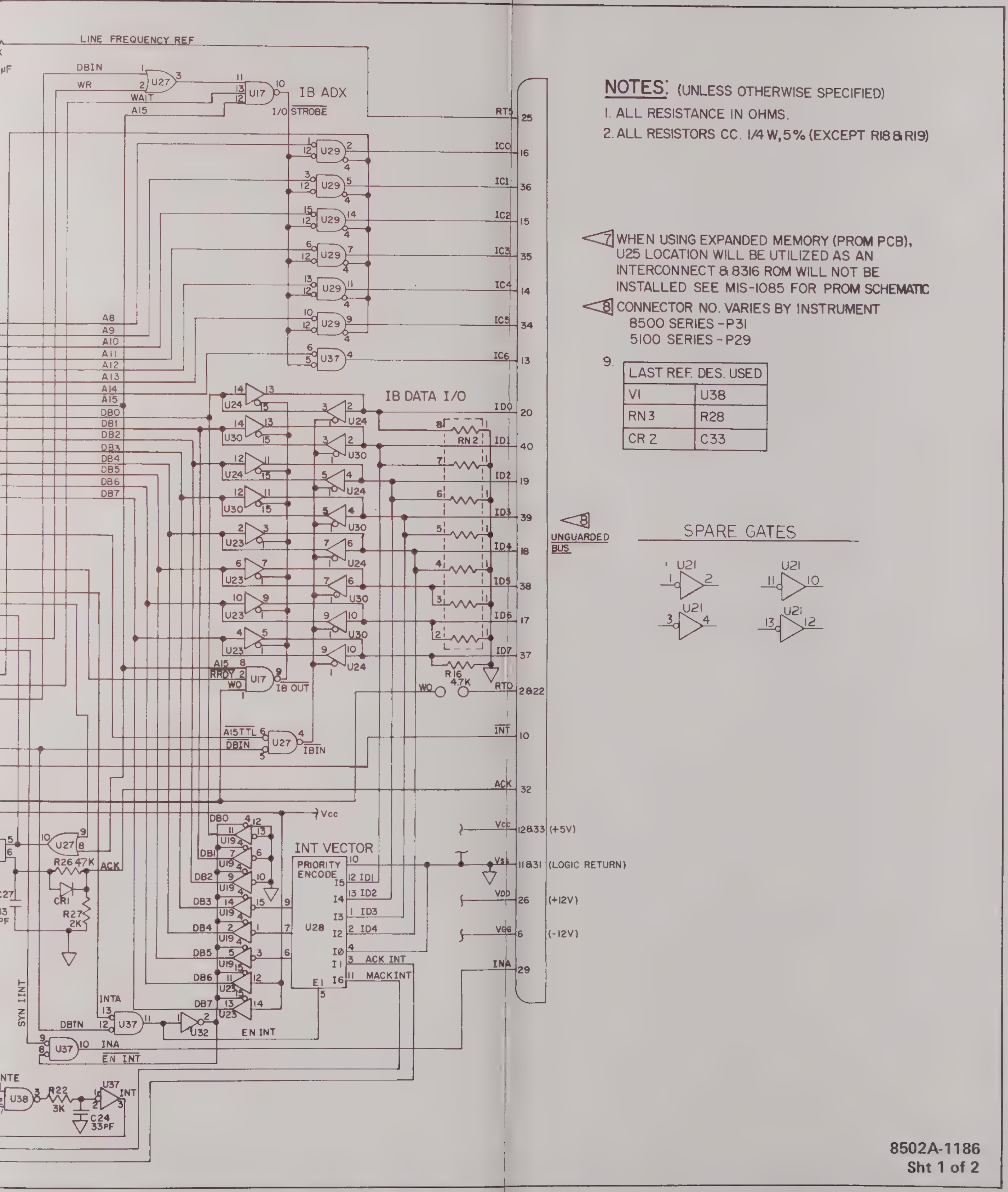

5
U6
C5
2
U13
C12
C14
20
U21
23
U24
R16
C21
29
U30
31
+
RN2
C32
RN3
8502A-1786

Figure 8-7. A6 Controller PCB Assembly—Single PCB Version


RESET
PHASE LOCK
SHAPER
LINE REF SHAPED
8 PERIOTS
RST
U34
U35
U36
ONE SHOT
LINE ACT.
LINE PERIODS
LINE INACTIVE
LINE REF SHAPED
C22
1μF
R18
23.2K
TP 4
R2 100 K
DLD
Vcc
C6 .047μF
RST TTL
U2
U32
NC
÷ 8
BIN CTR
ØLL
VcD OUT
SIG IN
VcD IN
U26
C20 .01 μF
R25 100K
R23 680K
R20 10K
R24 1.5K
C25 39μF
R21 6.8K
C18 15μF
C19 .22μF
U38
C28
RN3 10K
480Hz CLK
A8
A9
A10
A11
A12
A13
A14
A15
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
A14
A15 TTL
A15 TTL
IINT
RRDY
RRDY
INTA
INTA
A15+INTA
ACK LAT
WR
SYNIINT
HLDA
WAIT
DBIN
RST
INTE
INT
TTL PU
SYNC Ø2
RST TTL
ACK INT TTL
WO
Vcc
Vss
VDD
VBB
CONTINUED ON SHEET 2
RN1 4.7K
R17 4.99K
C26 2200 PF
SYNC Ø2
A15 TTL
U15
I/O TO
U14
ACK INT
ACK INT TTL
ACK INT
MARK INT
A15
TTL
SYNC
Ø2
DB4
U31
ARM CLK
PR
U1
R3 4.7K
RN1 4.7K
ARM MARK
RN1
480 Hz CLK
MARK INT
MARK INT
INTE
DLD ACK
INTA
RST
ACK INT
INT RST
INT
ACK INT
TP 5
IINT
INTE
DLD ACK
DBIN
U35
INT RST
R19 4.7K
IINT
INT
MARK INT
ACK INT
U17
MARK INT
ACK INT
INT. CONTROL
ACK LOGIC
U27
ACK LAT
DLD ACK
U15
DBIN
WO
U15-14
U31-14
U16-14
U1-16
C15 .01μF
C23 .01μF
C16 .01μF
C7 .01μF



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS CC. 1/4 W, 5% (EXCEPT R18 & R19)

7 WHEN USING EXPANDED MEMORY (PROM PCB), U25 LOCATION WILL BE UTILIZED AS AN INTERCONNECT & 8316 ROM WILL NOT BE INSTALLED SEE MIS-1085 FOR PROM SCHEMATIC

8 CONNECTOR NO. VARIES BY INSTRUMENT
8500 SERIES - P31
5100 SERIES - P29

9.

LAST REF. DES. USED	
VI	U38
RN 3	R28
CR 2	C33

LINE FREQUENCY REF
DBIN
WR
WAIT
A15
U27
U17
IB ADX
I/O STROBE
RTS 25
ICO 16
IC1 36
IC2 15
IC3 35
IC4 14
IC5 34
IC6 13
U29
U37
A8
A9
A10
A11
A12
A13
A14
A15
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
IB DATA I/O
U24
U30
U23
ID0 20
ID1 40
ID2 19
ID3 39
ID4 18
ID5 38
ID6 17
ID7 37
RN2
R16 4.7K
RRDY
WO
IB OUT
RTO 2&22
A15TTL
IBIN
INT 10
ACK 32
Vcc
Vcc 12&33 (+5V)
Vss 11&31 (LOGIC RETURN)
VDD 26 (+12V)
VGG 6 (-12V)
INA 29
UNGUARDED BUS
8
SPARE GATES
U21
INT VECTOR
PRIORITY ENCODE
U28
ACK INT
MACKINT
EN INT
U19
U25
U32
U37
INTA
DBIN
INA
EN INT
R26 47K
ACK
CR1
R27 2K
C27
SYN IINT
NTE
U38
R22 3K
C24 33PF
INT
8502A-1186
Sht 1 of 2

Figure 8-7. A6 Controller PCB Assembly— Single PCB Version (cont)

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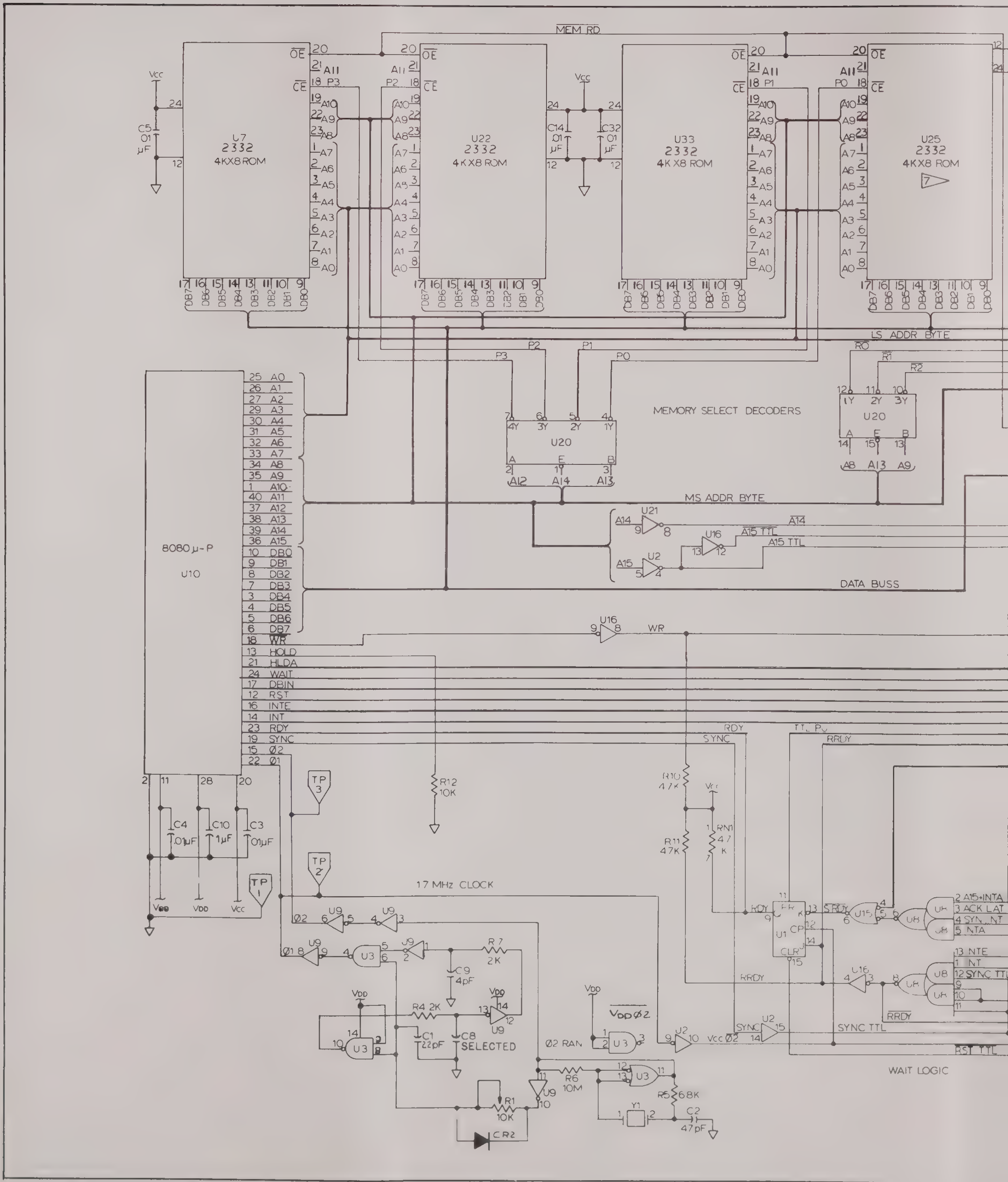
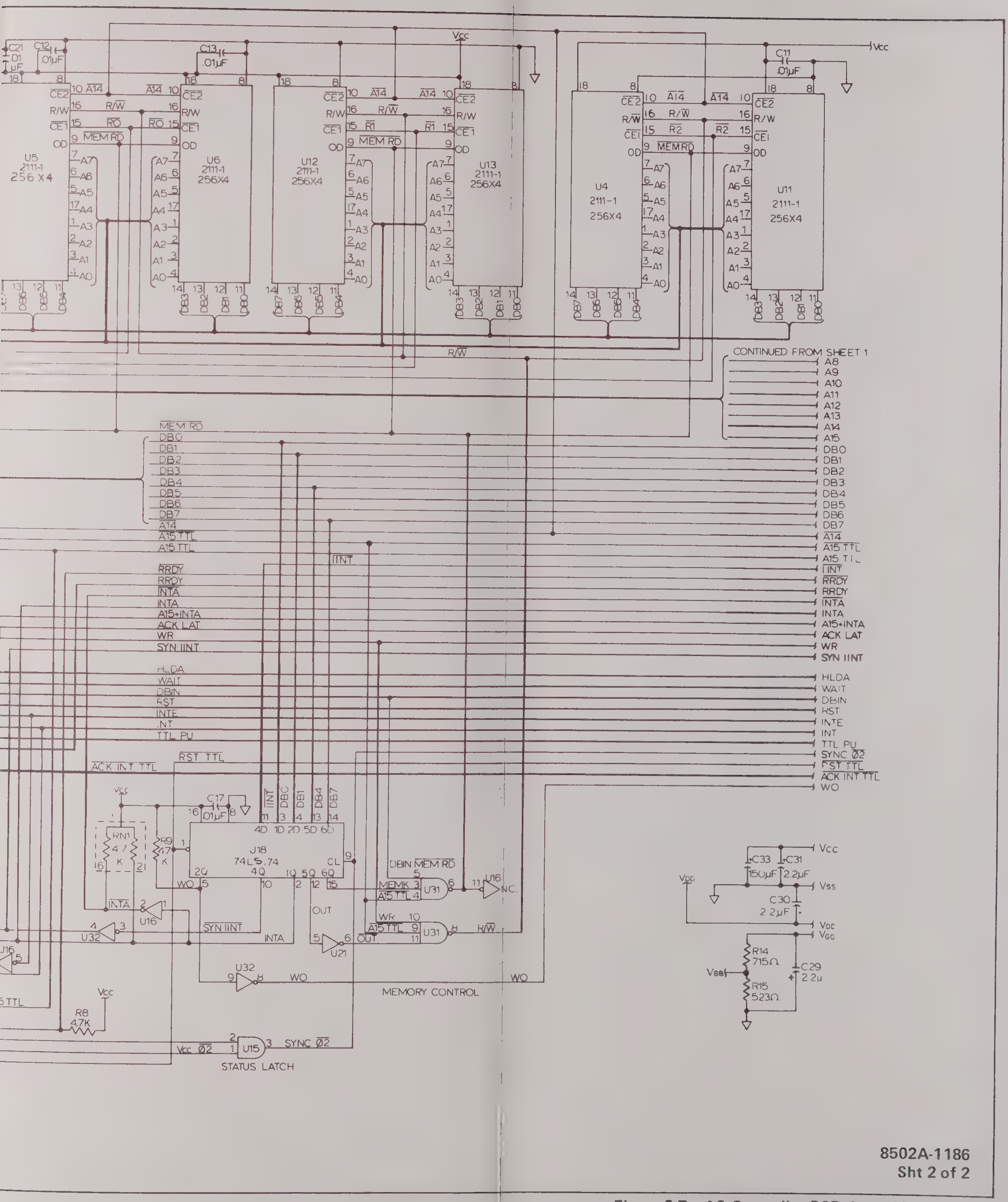
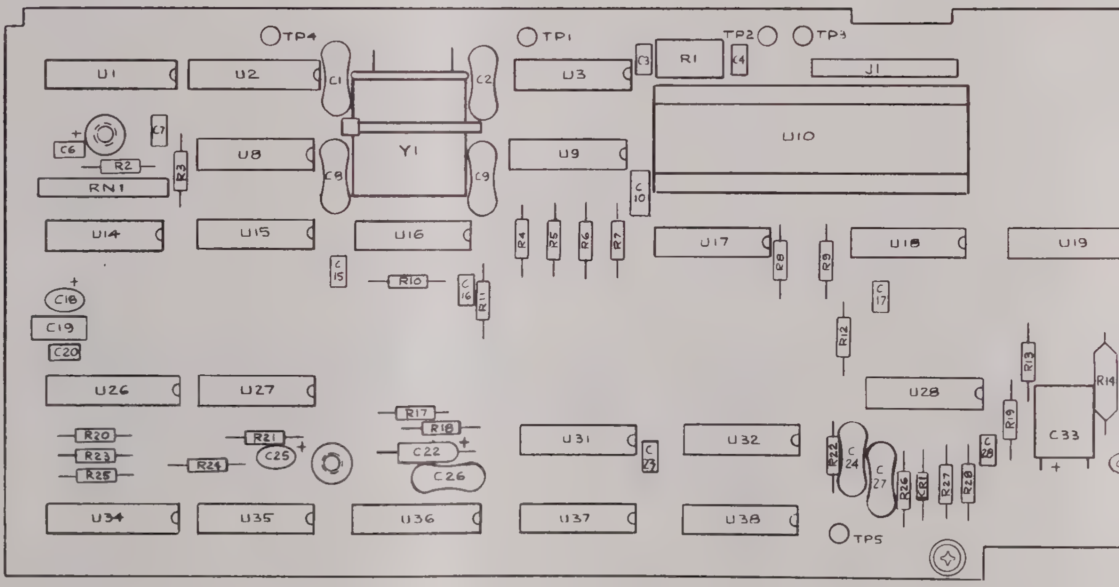


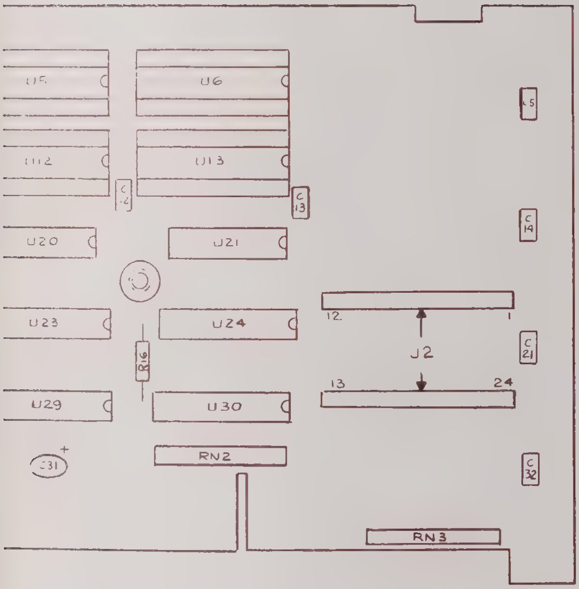
MEM RD
U7
2332
4KX8 ROM
U22
2332
4KX8 ROM
U33
2332
4K X8 ROM
U25
2332
4KX8 ROM
OE
CE
A11
P3
P2
P1
P0
Vcc
C5 .01 µF
C14 .01 µF
C32 .01 µF
DB7 DB6 DB5 DB4 DB3 DB2 DB1 DB0
LS ADDR BYTE
R0
R1
R2
MEMORY SELECT DECODERS
U20
4Y 3Y 2Y 1Y
A E B
A12 A14 A13
1Y 2Y 3Y
A8 A13 A9
MS ADDR BYTE
8080 µ-P
U10
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
DB0 DB1 DB2 DB3 DB4 DB5 DB6 DB7
WR
HOLD
HLDA
WAIT
DBIN
RST
INTE
INT
RDY
SYNC
Ø2
Ø1
U21
A14
U16
A15 TTL
U2
A15
DATA BUSS
TP 3
TP 2
TP 1
R12 10K
C4 .01µF
C10 1µF
C3 .01µF
VDD
Vcc
17 MHz CLOCK
U9
U3
R7 2K
C9 4pF
R4 2K
C1 22pF
C8 SELECTED
R1 10K
CR2
Ø2 RAN
VDD Ø2
R6 10M
R5 6.8K
Y1
C2 47pF
R10 4.7K
R11 47K
RN1 4.7 K
TTL P0
RRDY
U1
U15
U8
2 A15•INTA
3 ACK LAT
4 SYN..NT
5 NTA
13 NTE
1 NT
12 SYNC TTL
SYNC TTL
RST TTL
WAIT LOGIC


U5
2111-1
256 X4
U6
2111-1
256X4
U12
2111-1
256X4
U13
2111-1
256X4
U4
2111-1
256X4
U11
2111-1
256X4
C21 .01 µF
C12 .01µF
C13 .01µF
C11 .01µF
Vcc
CE2
R/W
CE1
OD
A14
MEM RD
R0
R1
R2
A7
A6
A5
A4
A3
A2
A1
A0
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
CONTINUED FROM SHEET 1
A8
A9
A10
A11
A12
A13
A15
A15 TTL
IINT
RRDY
INTA
A15+INTA
ACK LAT
WR
SYN IINT
HLDA
WAIT
DBIN
RST
INTE
INT
TTL PU
SYNC Ø2
RST TTL
ACK INT TTL
WO
C17 .01µF
RN1 4.7 K
R9 4.7 K
J18
74LS174
U16
U32
U21
U31
MEMR
OUT
NC
U15
Vcc Ø2
STATUS LATCH
MEMORY CONTROL
R8 4.7K
C33 150µF
C31 2.2µF
C30 2.2µF
C29 2.2µ
R14 715Ω
R15 523Ω
VDD
VSS
VGG
VBB

8502A-1186
Sht 2 of 2

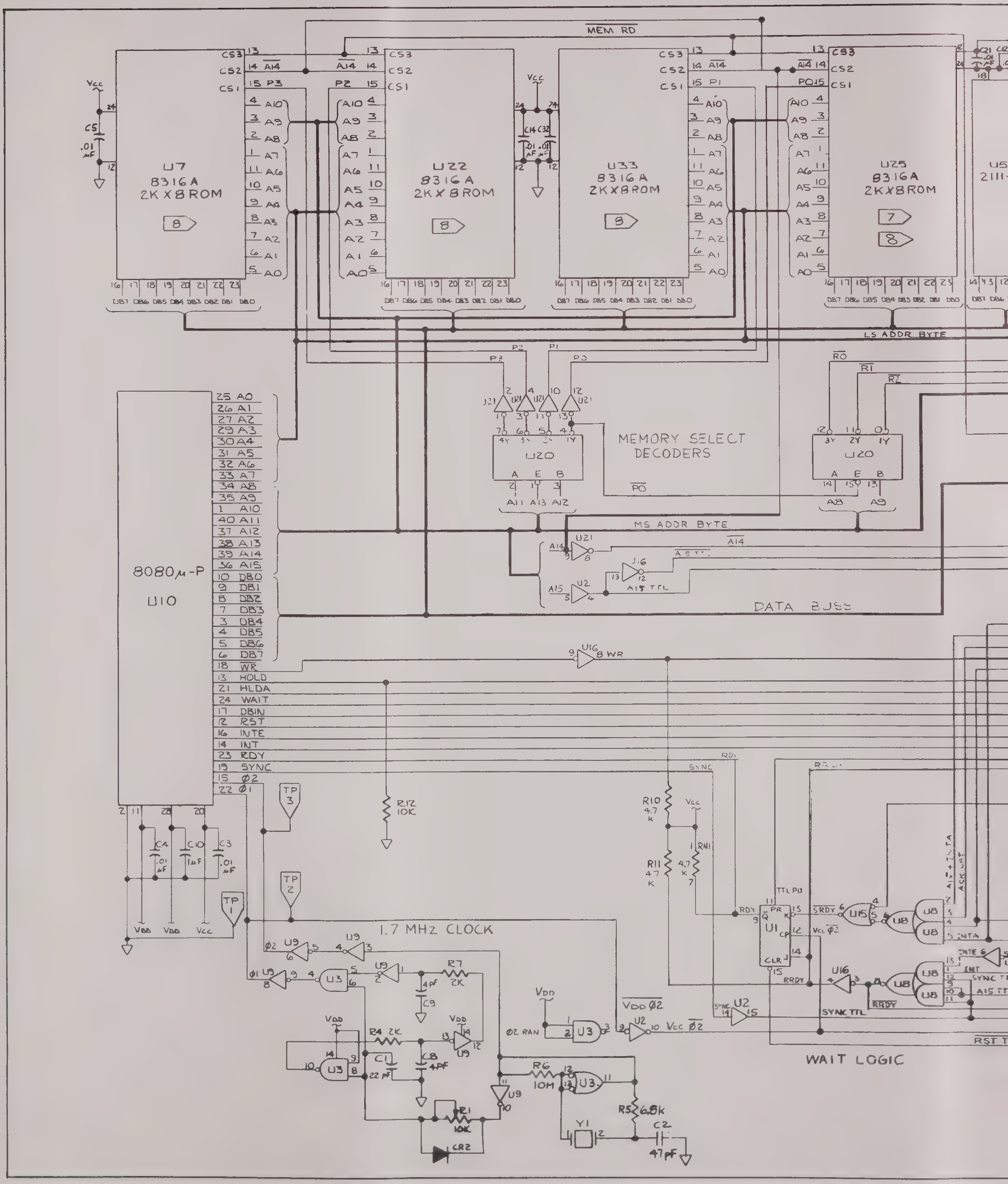
Figure 8-7. A6 Controller PCB Assembly—Single PCB Version (cont)


TP4
TP1
TP2
TP3
C3
R1
C4
J1
U1
U2
C1
C2
U3
U10
C7
C6
R2
R3
RN1
U8
Y1
C8
C9
U9
C10
U14
U15
U16
R4
R5
R6
R7
U17
R8
R9
U18
U19
C15
R10
C16
R11
C17
R12
C18
C19
C20
R13
R14
U26
U27
U28
R17
R18
R19
R20
R21
C22
C25
R23
R24
R25
C26
U31
C23
U32
R22
C24
C27
R26
CR1
R27
R28
C28
C33
U34
U35
U36
U37
U38
TP5


U5
U6
C15
U12
U13
C13
C14
U20
U21
U23
U24
12
1
J2
C21
R16
13
24
U29
U30
C31
RN2
C32
RN3

8502A-1785

Figure 8-8. A6A1 Controller PCB Assembly—Double PCB Version


MEM RD
U7
8316A
2K X 8 ROM
U22
8316A
2K X 8 ROM
U33
8316A
2K X 8 ROM
U25
8316A
2K X 8 ROM
CS3
CS2
CS1
A14
P3
P2
P1
P0
Vcc
C5
.01 μF
C14 C32
.01 .01 μF μF
DB7 DB6 DB5 DB4 DB3 DB2 DB1 DB0
LS ADDR BYTE
R0
R1
R2
U20
MEMORY SELECT DECODERS
A11 A13 A12
A8 A9
MS ADDR BYTE
U21
U2
U16
A14 TTL
A15 TTL
DATA BUSS
8080μ-P
U10
25 A0
26 A1
27 A2
29 A3
30 A4
31 A5
32 A6
33 A7
34 A8
35 A9
1 A10
40 A11
37 A12
38 A13
39 A14
36 A15
10 DB0
9 DB1
8 DB2
7 DB3
3 DB4
4 DB5
5 DB6
6 DB7
18 WR
13 HOLD
21 HLDA
24 WAIT
17 DBIN
12 RST
16 INTE
14 INT
23 RDY
19 SYNC
15 Ø2
22 Ø1
TP 3
TP 2
TP 1
R12 10K
C4 .01 μF
C10 1μF
C3 .01 μF
VBB VDD Vcc
1.7 MHz CLOCK
U9
U3
R7 2K
C9 4pF
R4 2K
C1 22 pF
C8 4pF
R1 10K
CR2
Ø2 RAN
VDD Ø2
Vcc Ø2
R6 10M
R5 6.8k
Y1
C2 47pF
R10 4.7 K
R11 4.7 K
RN1
U1
TTL PU
RDY
SRDY
U15
U8
RRDY
SYNC TTL
INT
A15 TTL
RST T
WAIT LOGIC

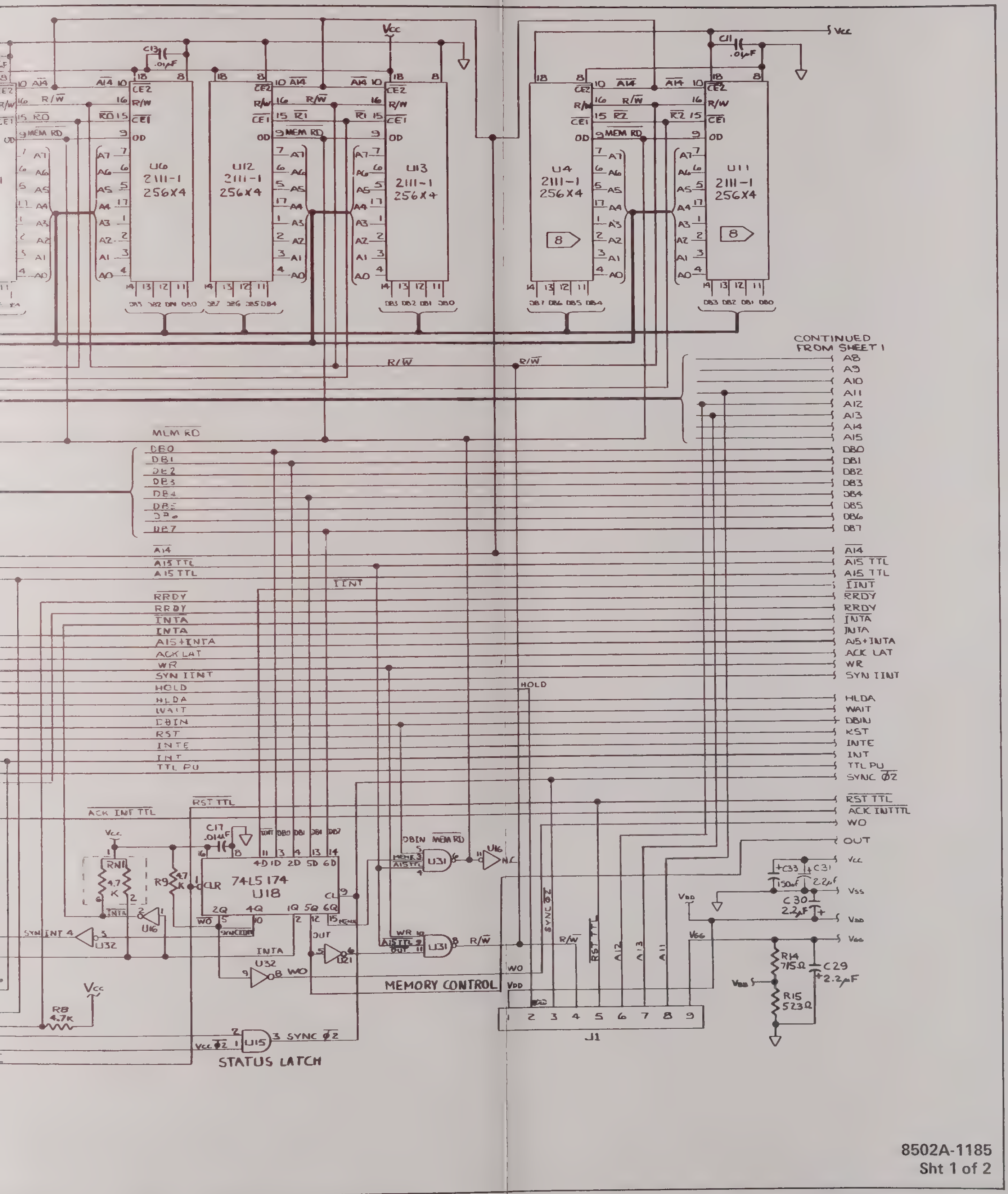

Vcc
C13 .01µF
C11 .01µF
U6 2111-1 256X4
U12 2111-1 256X4
U13 2111-1 256X4
U4 2111-1 256X4
U11 2111-1 256X4
CE2
R/W
CE1
OD
A7
A6
A5
A4
A3
A2
A1
A0
A14
R/W
R0
R1
R2
MEM RD
DB3 DB2 DB1 DB0
DB7 DB6 DB5 DB4
CONTINUED FROM SHEET 1
A8
A9
A10
A11
A12
A13
A14
A15
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
A14
A15 TTL
A15 TTL
IINT
RRDY
RRDY
INTA
INTA
A15+INTA
ACK LAT
WR
SYN IINT
HOLD
HLDA
WAIT
DBIN
RST
INTE
INT
TTL PU
SYNC Ø2
RST TTL
ACK INT TTL
WO
OUT
Vcc
Vss
VDD
VBB
C33 150µF
C31 2.2µF
C30 2.2µF
R14 715Ω
R15 523Ω
C29 2.2µF
J1
RN1 4.7K
R9 4.7K
C17 .014µF
74LS174 U18
CLR
U16
U32
SYN INT 4
U31
U21
N.C.
DBIN
MEM RD
AIS TTL
WR
R/W
INTA
WO
OUT
MEMORY CONTROL
R8 4.7K
U15
SYNC Ø2
STATUS LATCH
SYNC Ø2
RST TTL
A12
A13
A11
8502A-1185
Sht 1 of 2

Figure 8-8. A6A1 Controller PCB Assembly—Double PCB Version (cont)

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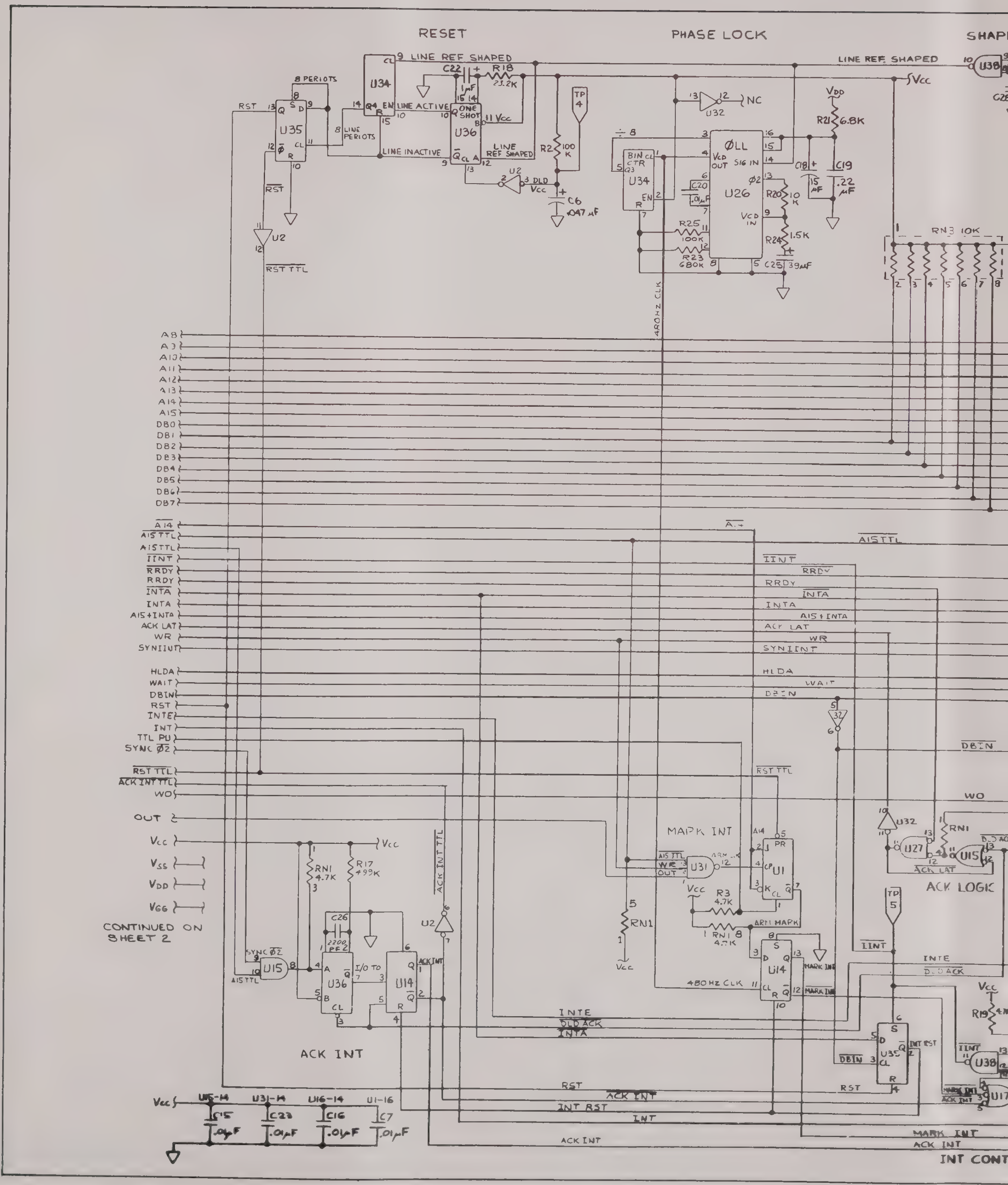
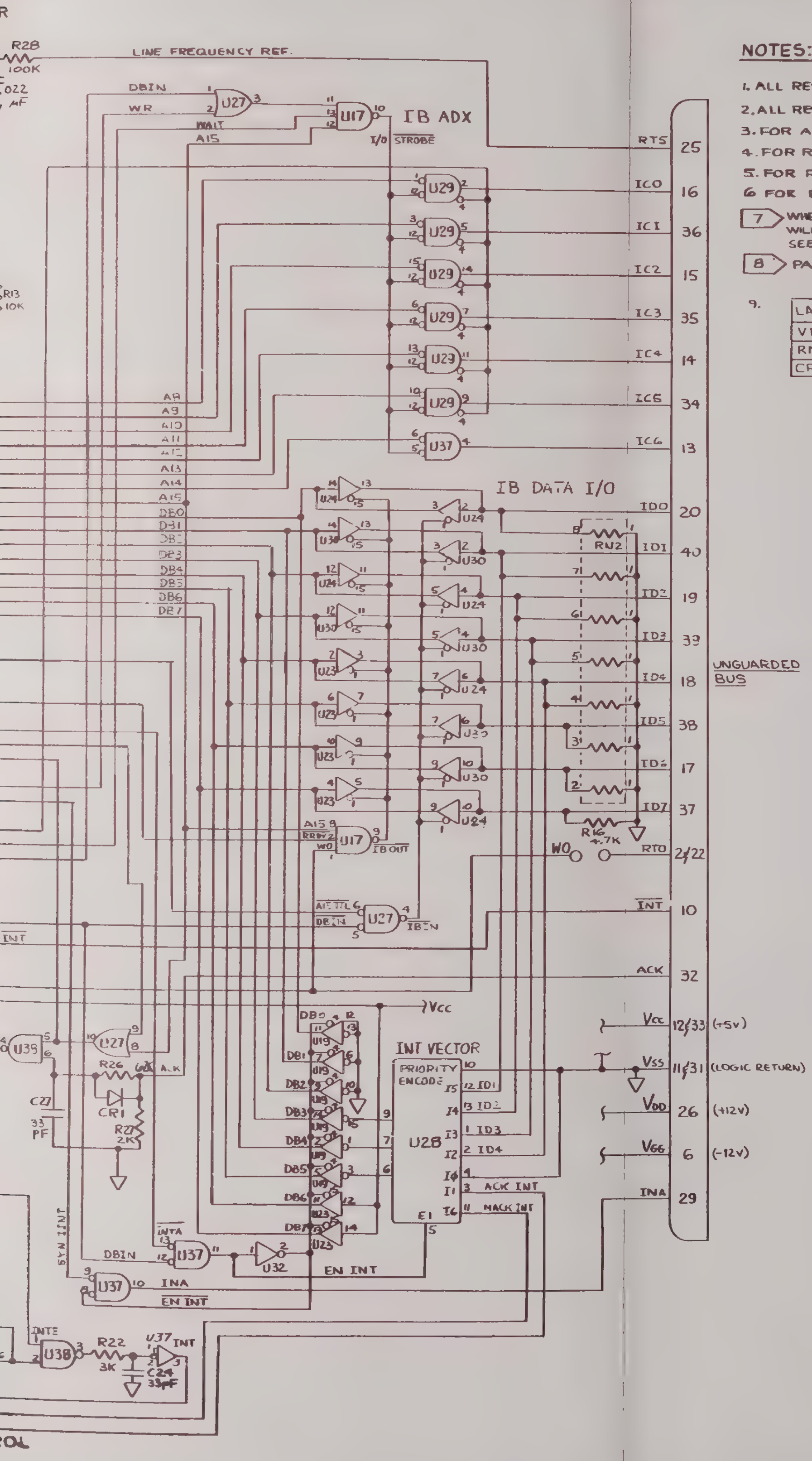
RESET
PHASE LOCK
SHAP
LINE REF SHAPED
U34
U35
U36
ONE SHOT
8 PERIODS
8 LINE PERIODS
LINE ACTIVE
LINE INACTIVE
LINE REF SHAPED
C22 1μF
R18 23.2K
R2 100K
TP 4
U2
DLD
C6 .047μF
RST
RST
RST TTL
NC
U32
÷8
BIN CTR
U34
ØLL
U26
VCO OUT
SIG IN
VCO IN
C20 .01μF
R25 100K
R23 680K
R20 10K
R24 1.5K
C25 39μF
C18 15μF
C19 .22μF
R21 6.8K
VDD
Vcc
U38
RN3 10K
480HZ CLK
A8
A9
A10
A11
A12
A13
A14
A15
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
A14
A15 TTL
A15TTL
IINT
RRDY
RRDY
INTA
INTA
A15+INTA
ACK LAT
WR
SYNIINT
HLDA
WAIT
DBIN
RST
INTE
INT
TTL PU
SYNC Ø2
RST TTL
ACK INT TTL
WO
OUT
Vcc
Vss
VDD
VGG
CONTINUED ON SHEET 2
RN1 4.7K
R17 499K
C26 2200 PF
U15
U36
U14
I/O TO
ACK INT
ACK INT TTL
ACK INT
MARK INT
U31
U1
A15 TTL
WR
OUT
ARM MARK
R3 4.7K
RN1 8 4.7K
RN1
U14
MARK INT
U32
U27
U15
RN1
DLD ACK
ACK LAT
ACK LOGIC
TP 5
IINT
INTE
DLD ACK
R19
U35
INT RST
DBIN
U38
U17
MARK INT
ACK INT
INTE
DLD ACK
INTA
RST
ACK INT
INT RST
INT
ACK INT
MARK INT
ACK INT
INT CONT
U15-14
U31-14
U16-14
U1-16
C15 .01μF
C23 .01μF
C16 .01μF
C7 .01μF


LINE FREQUENCY REF.
R28
100K
.022
µF
DBIN
WR
WAIT
A15
U27
U17
IB ADX
I/O STROBE
RTS 25
ICO 16
IC1 36
IC2 15
IC3 35
IC4 14
IC5 34
IC6 13
U29
U37
A8
A9
A10
A11
A12
A13
A14
A15
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
R13
10K
IB DATA I/O
U24
U30
U23
RN2
IDO 20
ID1 40
ID2 19
ID3 39
ID4 18
ID5 38
ID6 17
ID7 37
UNGUARDED BUS
R16
4.7K
IB OUT
WO
RTO 21/22
INT 10
IBEN
ACK 32
Vcc
Vcc 12/33 (+5V)
Vss 11/31 (LOGIC RETURN)
VDD 26 (+12V)
VGG 6 (-12V)
INA 29
INT VECTOR
PRIORITY ENCODE
U28
ACK INT
NACK INT
EN INT
E1
U19
U38
R26
CR1
C27
33 PF
R27
2K
INT
INTA
DBIN
U32
SYN INT
INA
EN INT
INTE
R22
3K
C24
33pF

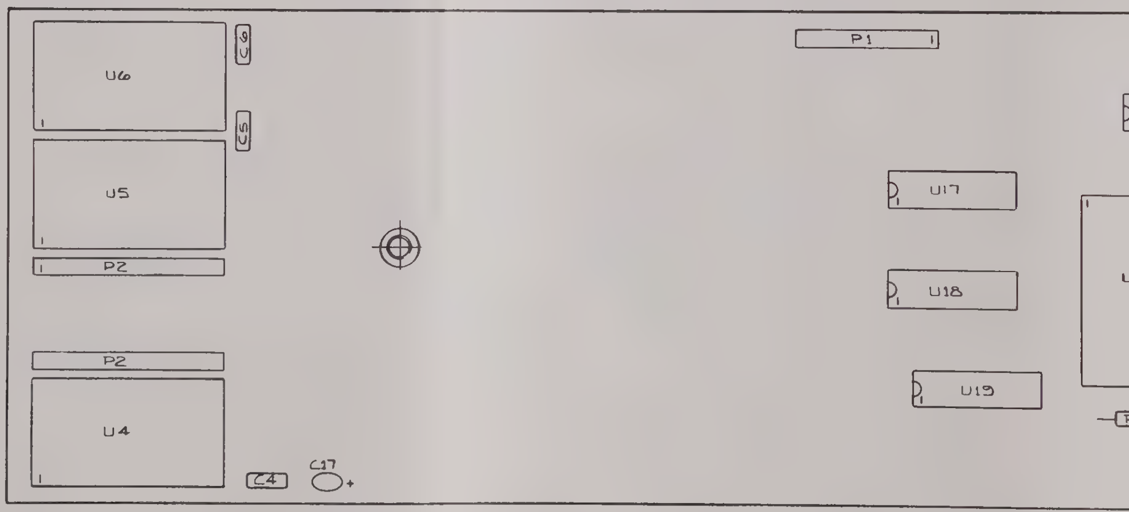
NOTES: (UNLESS OTHERWISE SPECIFIED)

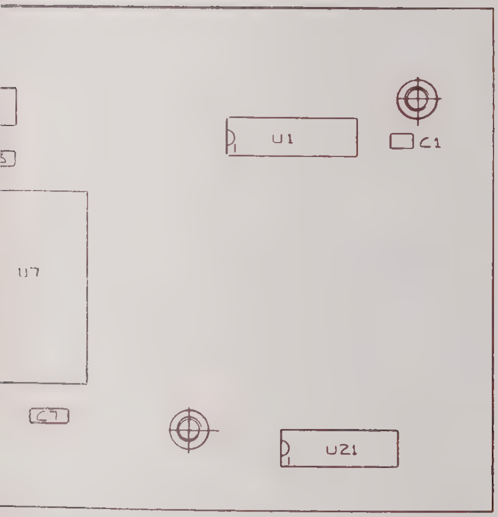
1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS CC. 1/4 W, 5%. (EXCEPT R18 & R17)
3. FOR ASSY DRAWING SEE 8502A-4185.
4. FOR REF. DES. DRAWING SEE 8502A-1785.
5. FOR PCB SEE MIS 3185.
6 FOR BLOCK DIAGRAM SEE 8502A-1485.
7 WHEN USING EXPANDED MEMORY (PROM PCB), U25 LOCATION WILL BE UTILIZED AS AN INTERCONNECT, SEE 8502A-1088 SCHEMATIC.
8 PARTS NOT USED ON THIS ASSY.
9.

LAST REF. DES. USED	
V1	U38
RN 3	R28
CR1	C33

8502A-1185
Sht 2 of 2

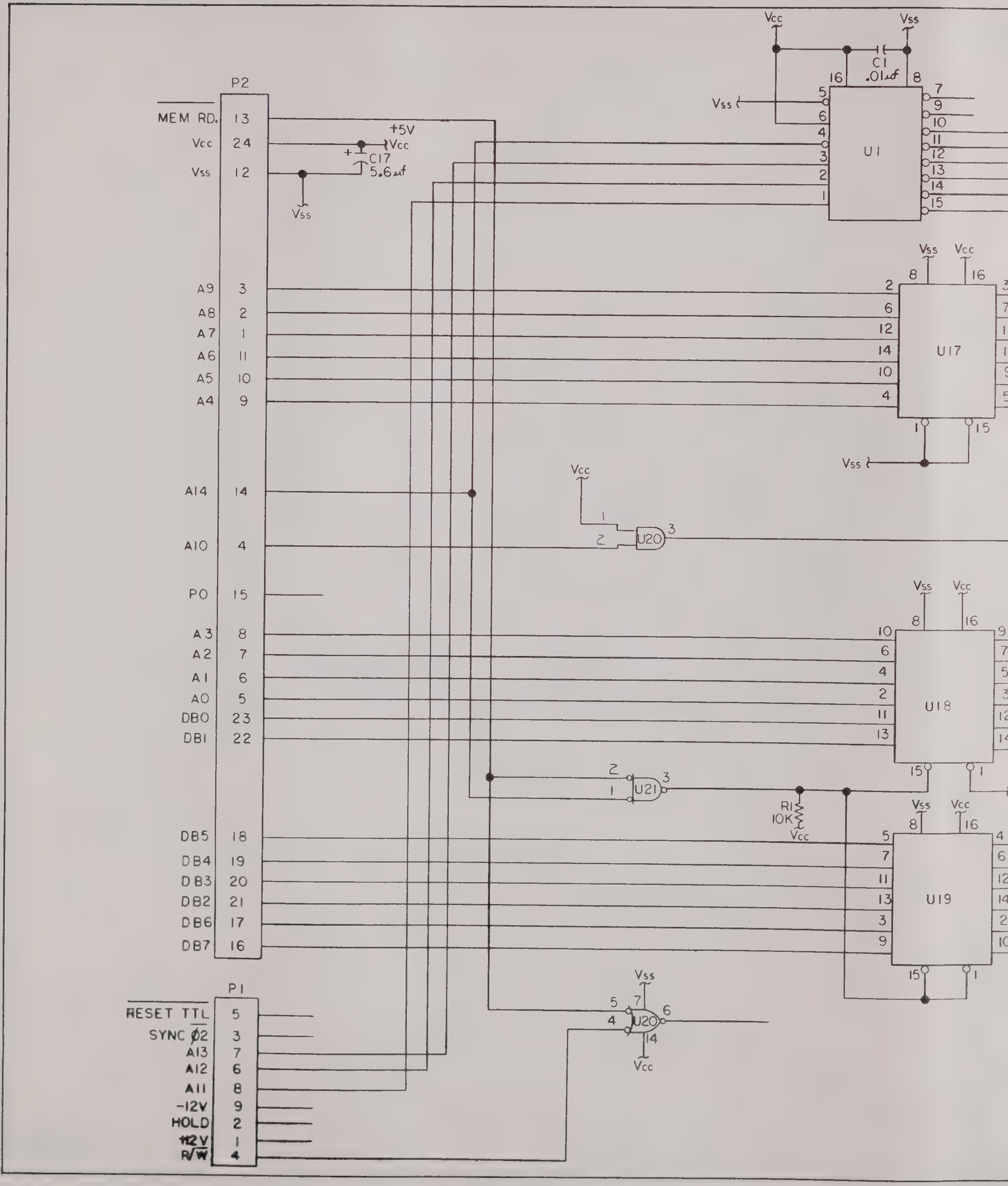
Figure 8-8. A6A1 Controller PCB Assembly—Double PCB Version (cont)


U6
C6
C5
U5
P2
P2
U4
C4
C17
P1
U17
U18
U19


U1
C1
U7
C7
U21
5

8502A-1688

Figure 8-9. A6A2 Prom Rom PCB Assembly—
Double PCB Version


P2
MEM RD. 13
Vcc 24
Vss 12
+5V
Vcc
C17 5.6 µf
Vss
A9 3
A8 2
A7 1
A6 11
A5 10
A4 9
A14 14
A10 4
P0 15
A3 8
A2 7
A1 6
A0 5
DB0 23
DB1 22
DB5 18
DB4 19
DB3 20
DB2 21
DB6 17
DB7 16
P1
RESET TTL 5
SYNC Ø2 3
A13 7
A12 6
A11 8
-12V 9
HOLD 2
+12V 1
R/W 4
Vcc
Vss
C1 .01µf
U1
U17
U18
U19
U20
U21
R1 10K
Vcc
Vss

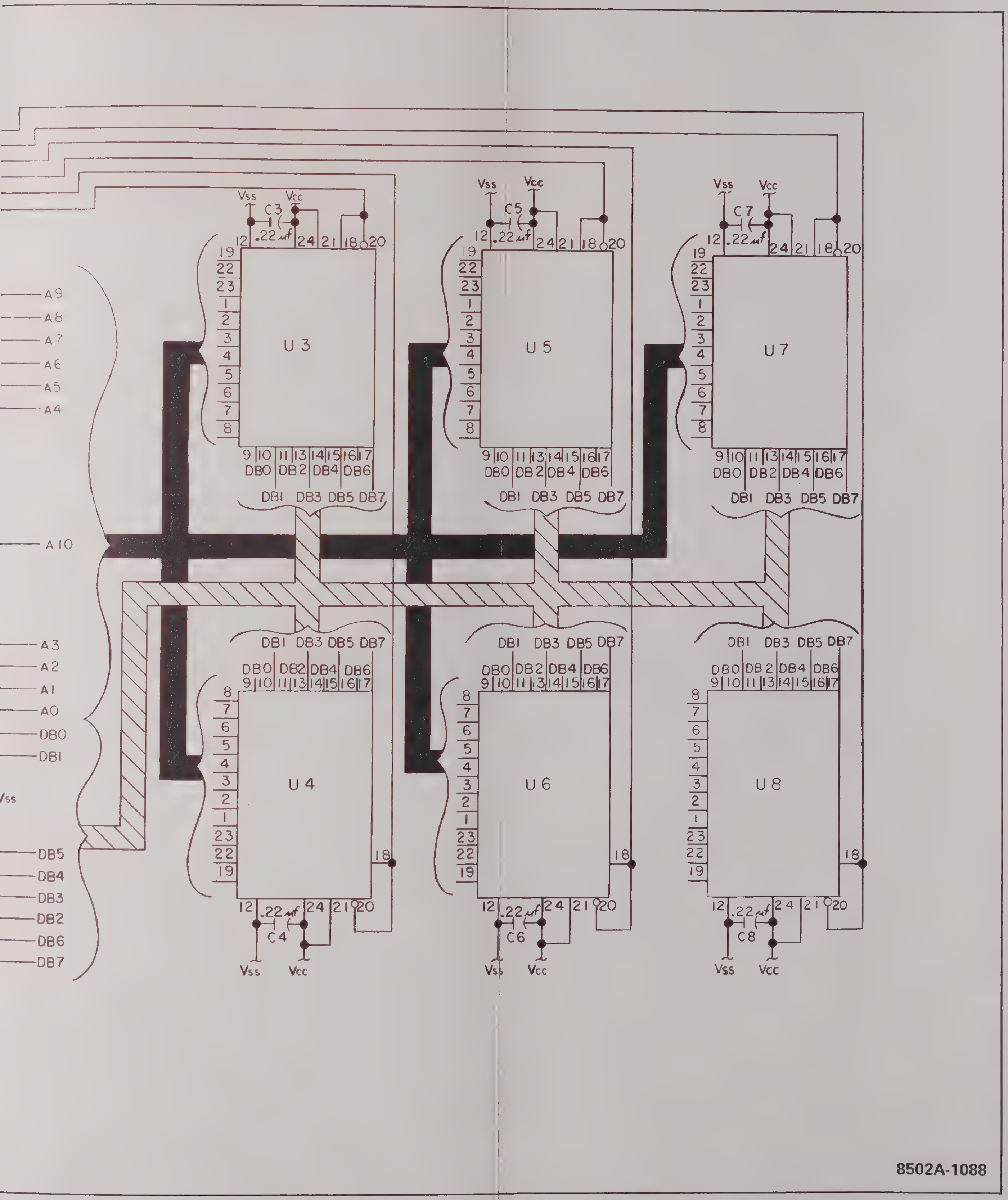
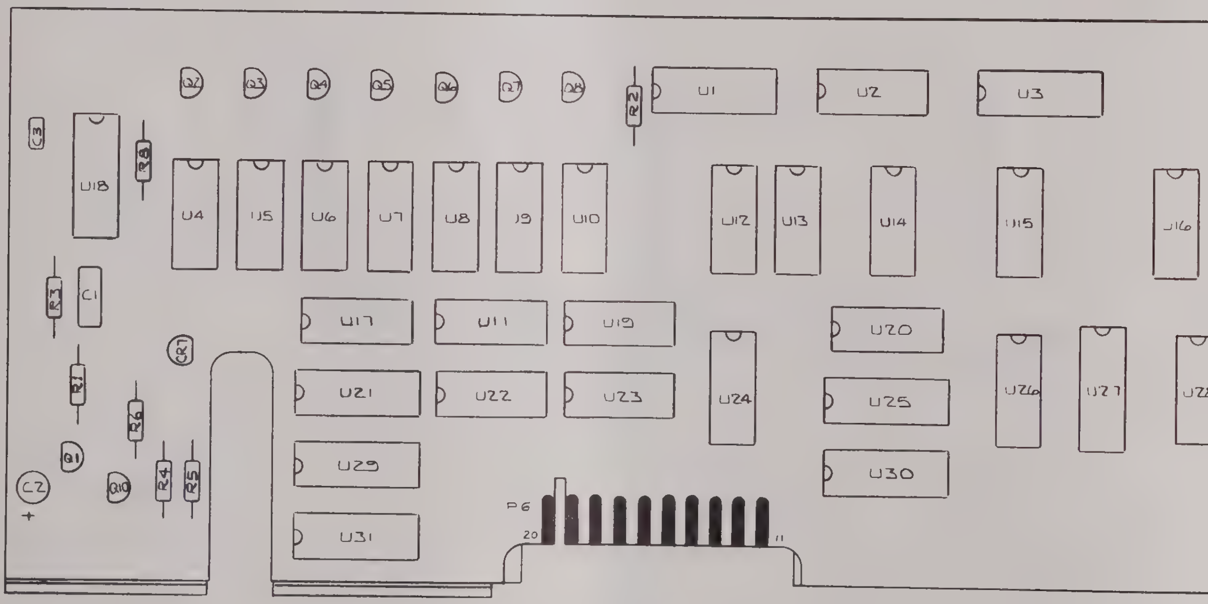
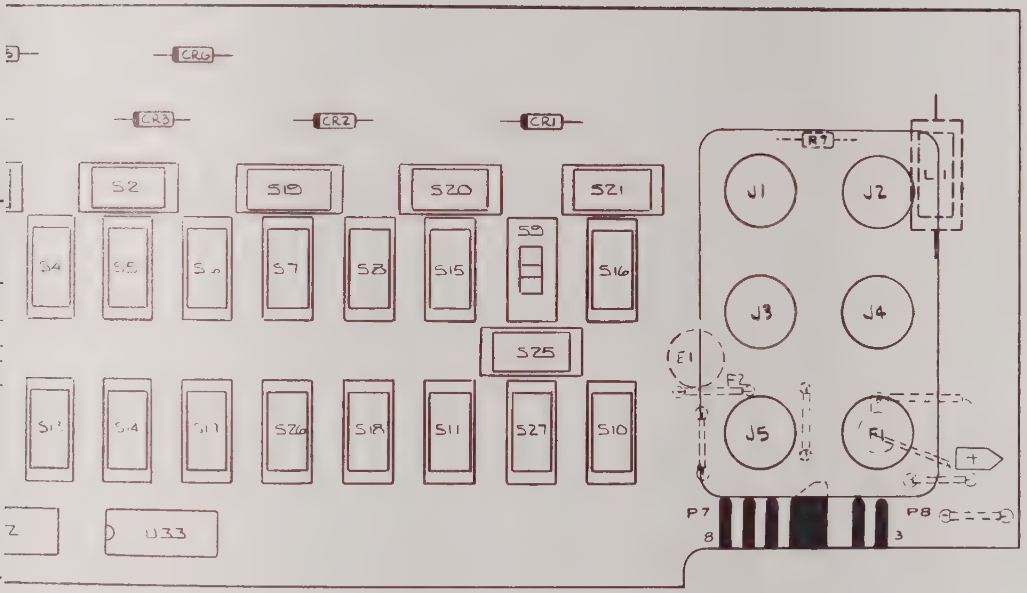

Vss
Vcc
C3
.22 uf
U3
U4
U5
U6
U7
U8
C4
C5
C6
C7
C8
A9
A8
A7
A6
A5
A4
A10
A3
A2
A1
A0
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
8502A-1088

Figure 8-9. A6A2 Prom Rom PCB Assembly—Double PCB Version (cont)


Q2
Q3
Q4
Q5
Q6
Q7
Q8
R2
U1
U2
U3
C3
U18
R8
U4
U5
U6
U7
U8
U9
U10
U12
U13
U14
U15
U16
R3
C1
U17
U11
U19
U20
CR1
R1
R6
U21
U22
U23
U24
U25
U26
U27
Q1
C2
+
Q10
R4
R5
U29
U30
P6
20
11
U31

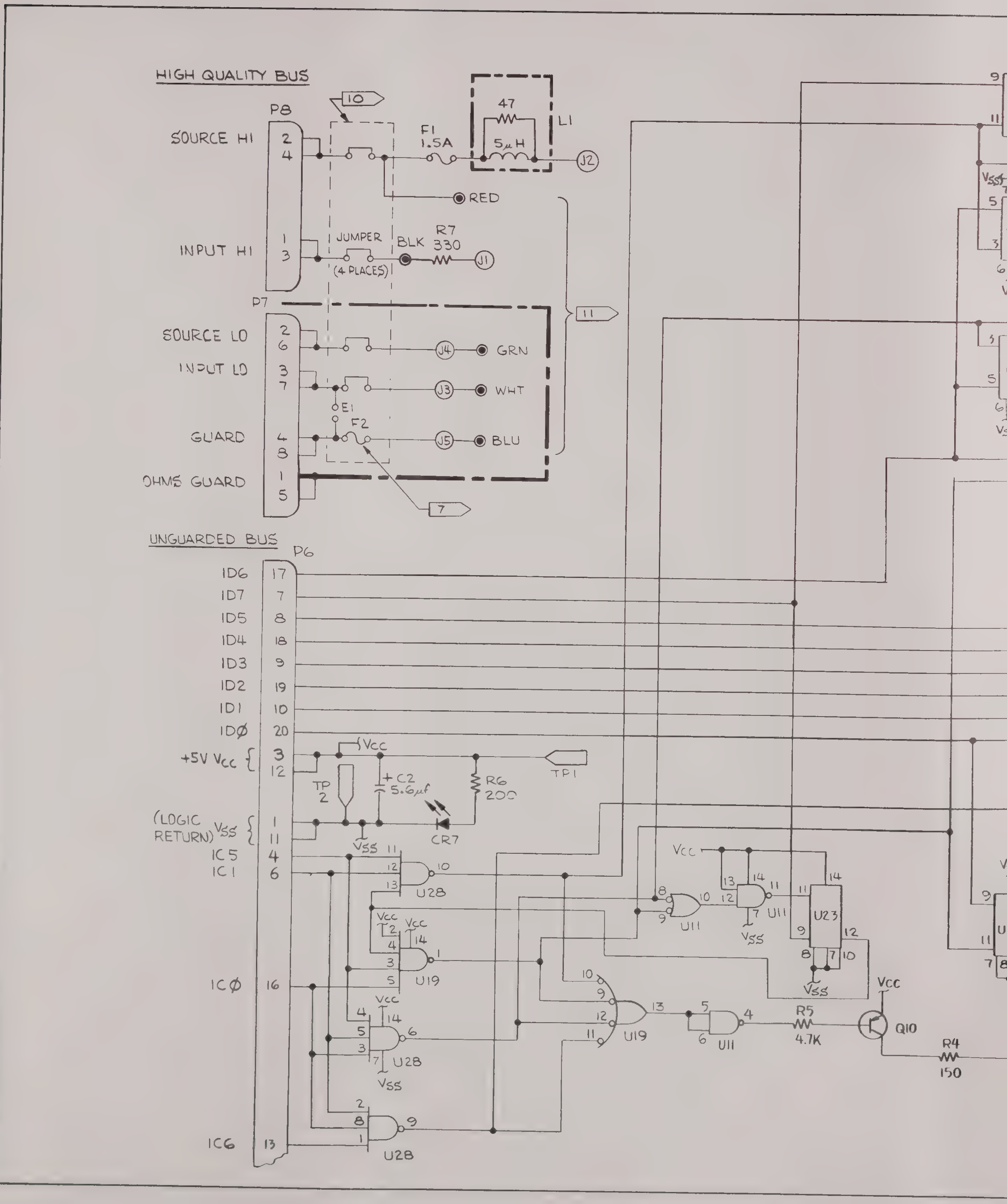

CR6
CR3
CR2
CR1
R7
L1
S2
S19
S20
S21
J1
J2
S4
S5
S7
S8
S15
S9
S16
J3
J4
S25
E1
F2
S14
S17
S26
S18
S11
S27
S10
J5
F1
+
U33
P7
8
3
P8

NOTES:

4 JUMPER AND FUSE CONNECTIONS, FAR SIDE.

8502A-1623

Figure 8-10. A7 Front Panel Display PCB Assembly


HIGH QUALITY BUS
P8
SOURCE HI
INPUT HI
10
F1 1.5A
47
5μH
L1
J2
RED
JUMPER
(4 PLACES)
BLK
R7 330
J1
P7
11
SOURCE LO
INPUT LO
GUARD
OHMS GUARD
J4 GRN
J3 WHT
J5 BLU
E1
F2
7
UNGUARDED BUS
P6
ID6 17
ID7 7
ID5 8
ID4 18
ID3 9
ID2 19
ID1 10
ID0 20
+5V Vcc 3 12
Vcc
C2 5.6μf
R6 200
TP1
TP 2
(LOGIC RETURN) Vss 1 11
CR7
Vss
IC5 4
IC1 6
IC0 16
IC6 13
U28
U19
U11
U23
Vcc
Vss
R5 4.7K
Q10
R4 150

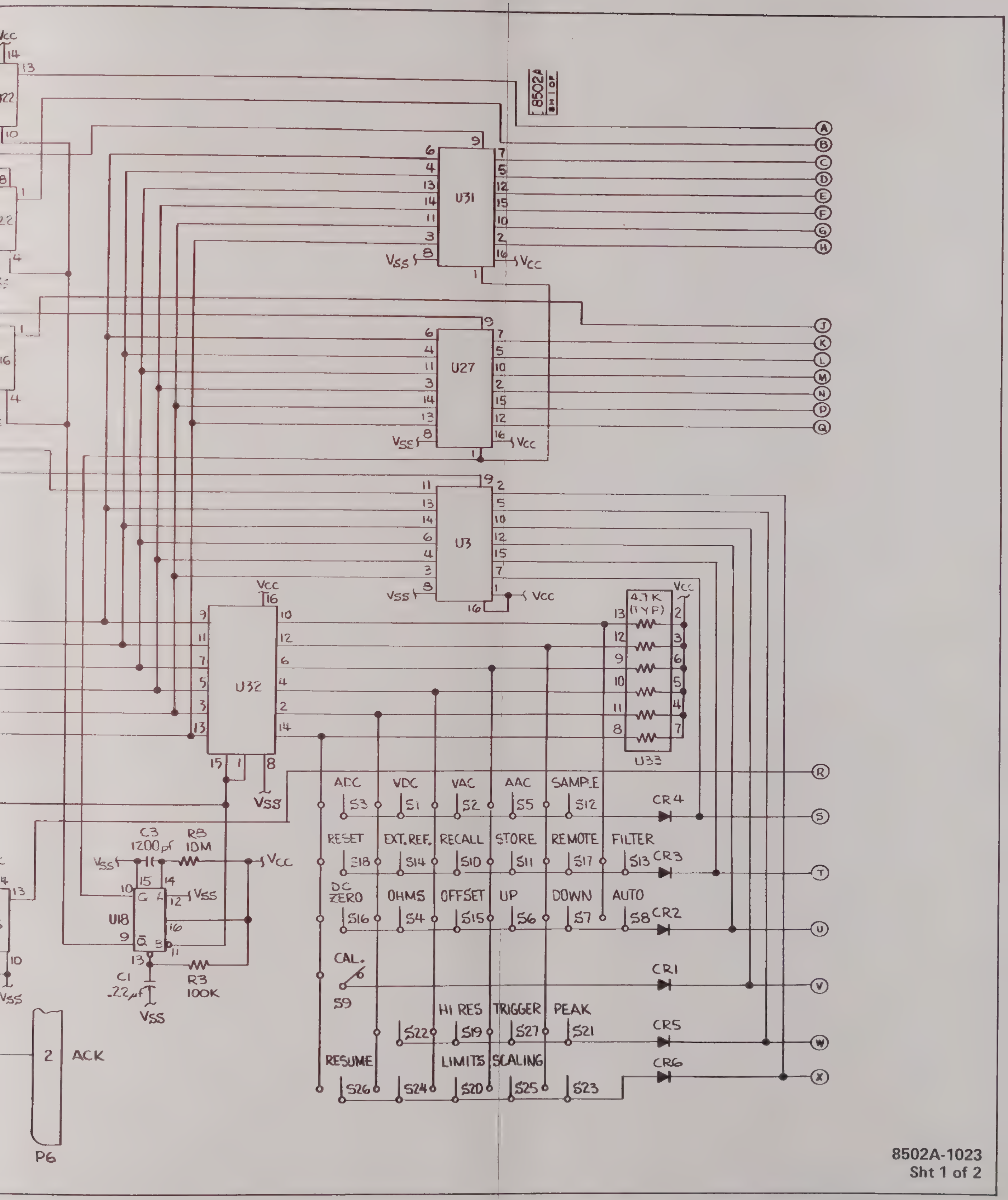

8502A SH OF
U31
U27
U3
U32
U33
4.7K (TYP)
U18
U22
P6
2 ACK
Vcc
Vss
C3 1200pf
R8 10M
C1 .22μf
R3 100K
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q
R
S
T
U
V
W
X
ADC S3
VDC S1
VAC S2
AAC S5
SAMPLE S12
CR4
RESET S18
EXT. REF. S14
RECALL S10
STORE S11
REMOTE S17
FILTER S13
CR3
DC ZERO S16
OHMS S4
OFFSET S15
UP S6
DOWN S7
AUTO S8
CR2
CAL. S9
CR1
HI RES S19
TRIGGER S27
PEAK S21
S22
CR5
RESUME S26
S24
LIMITS S20
SCALING S25
S23
CR6
8502A-1023
Sht 1 of 2

Figure 8-10. A7 Front Panel Display PCB Assembly (cont)

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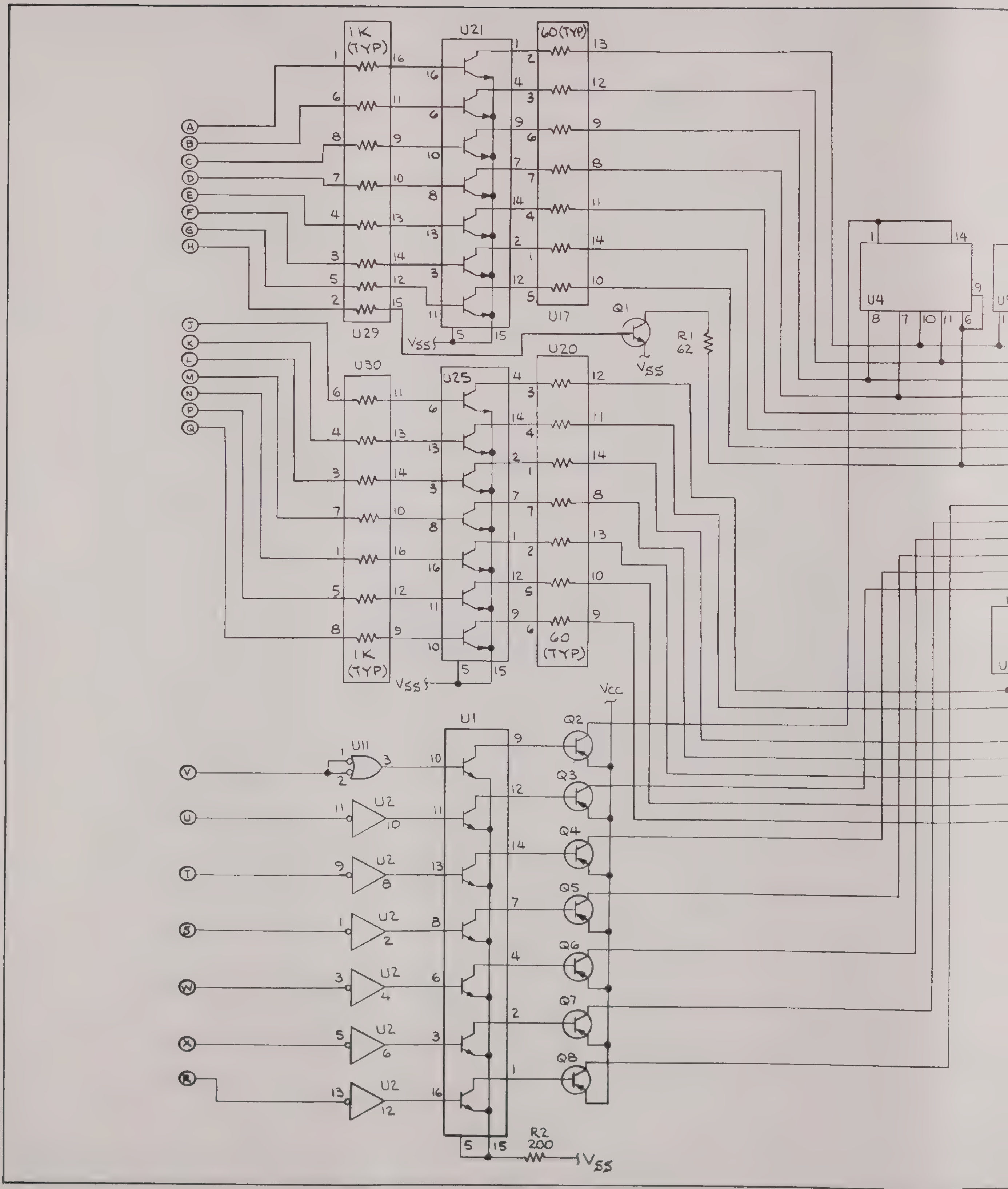
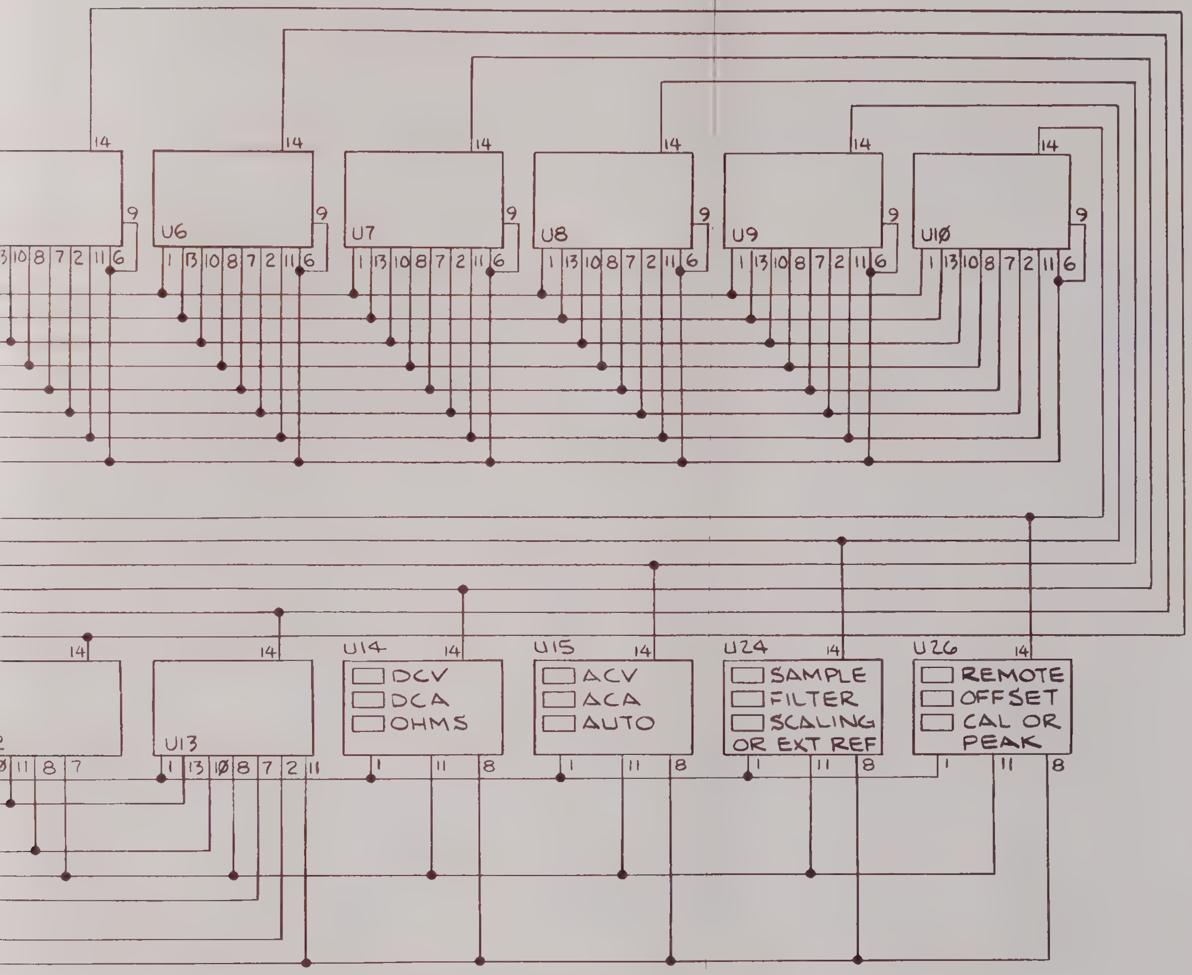
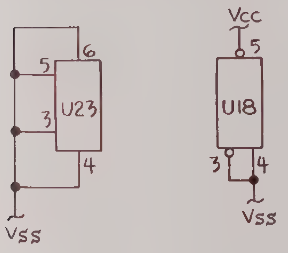

A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q
V
U
T
S
W
X
R
1K (TYP)
U29
U21
60 (TYP)
U17
Q1
R1 62
VSS
U30
U25
U20
1K (TYP)
60 (TYP)
U4
VCC
U1
U11
U2
Q2
Q3
Q4
Q5
Q6
Q7
Q8
R2 200


U6
U7
U8
U9
U1Ø
U13
U14
☐ DCV
☐ DCA
☐ OHMS
U15
☐ ACV
☐ ACA
☐ AUTO
U24
☐ SAMPLE
☐ FILTER
☐ SCALING OR EXT REF
U26
☐ REMOTE
☐ OFFSET
☐ CAL OR PEAK
14
9
1
13
10
8
7
2
11
6


U23
U18
Vcc
Vss
Vss
5
6
3
4

NOTES: (UNLESS OTHERWISE SPECIFIED)

4. ALL RESISTANCE VALUES IN OHMS.

5. REF. DES. NUMBERS NOT USED - Q9.

6. LAST REF DES USED - J5, C3, Q10, U33, S27, R8, CR7, L1, E1, F2.

7. #36 WIRE x.50 LONG AND #22 TEFLON SLEEVING.

8. FOR MOTHER INTERCONNECT DIAGRAM, SEE 8500A-1301

9. S22, S23, & S24 NOT USED

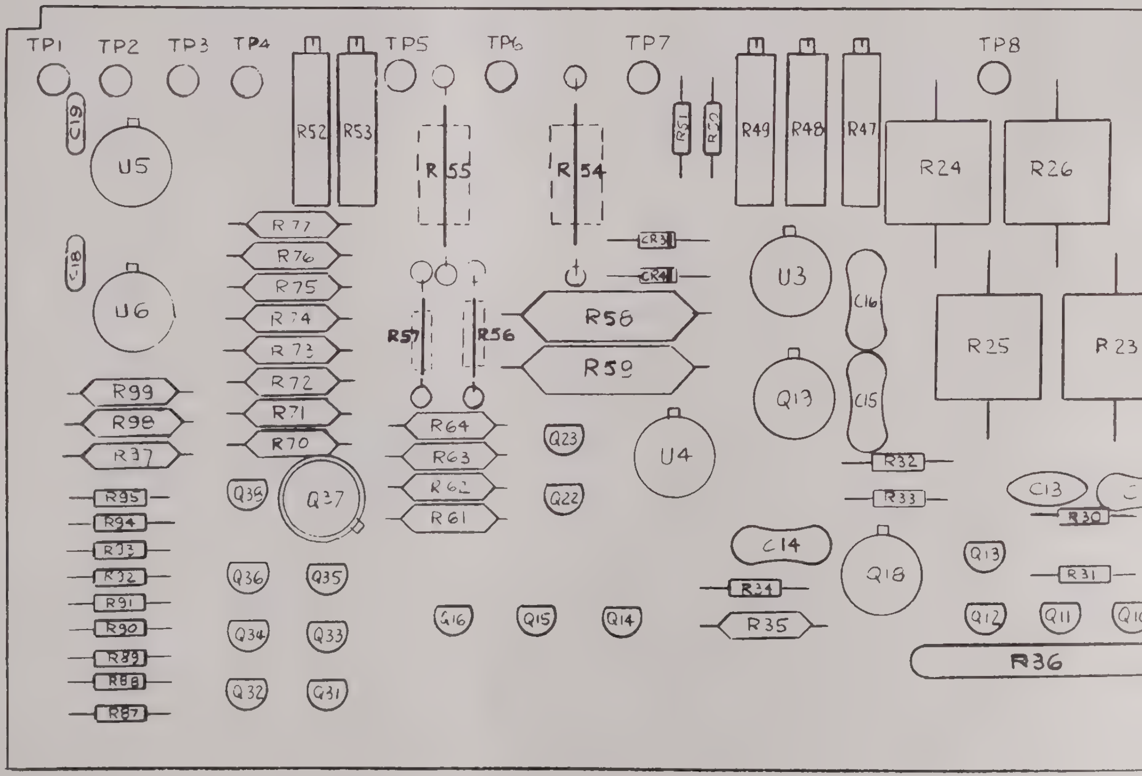
10. E1, F2 & JUMPERS ARE REMOVED ON -16 OPTION ONLY.

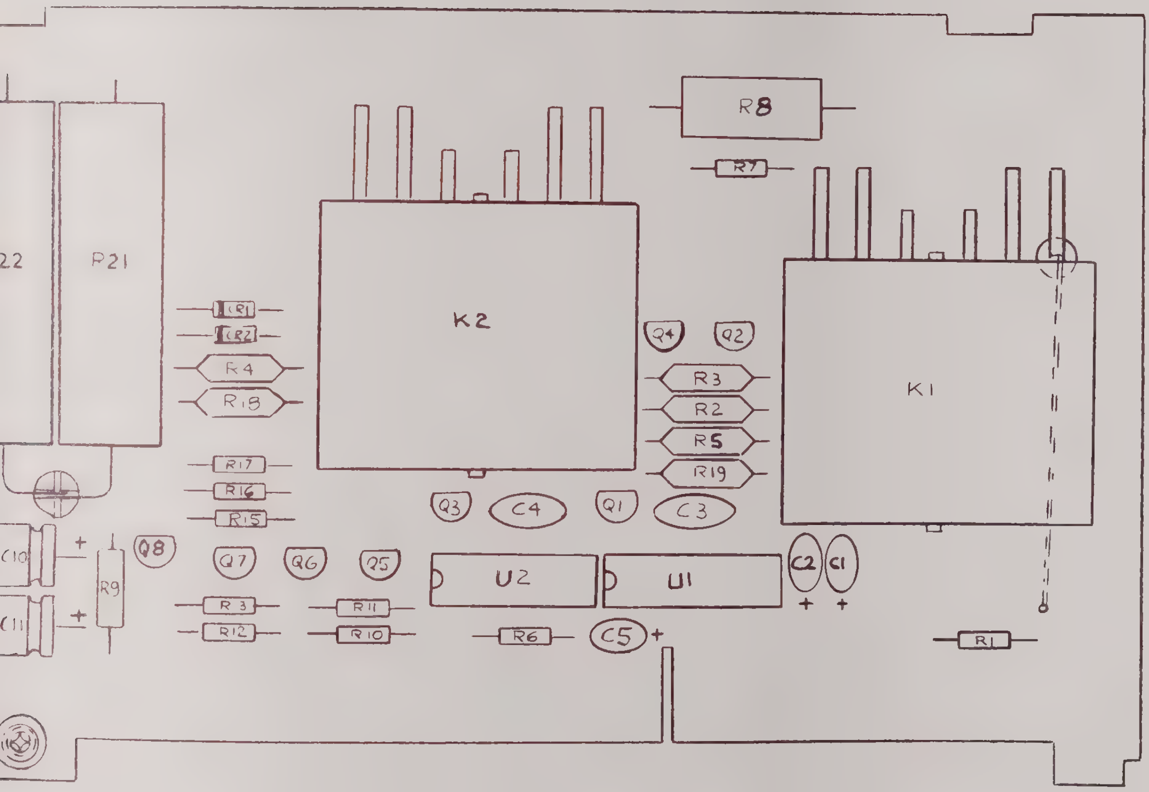
11. CABLE, FRONT INPUT, INSTALLED ON -16 OPTION ONLY.

8502A-1023
Sht 2 of 2

Figure 8-10. A7 Front Panel Display PCB Assembly (cont)

R54, R55, R56 & R57 WILL BE DETERMINED
DURING TESTING. RESISTORS MAY BE INSTALLED.

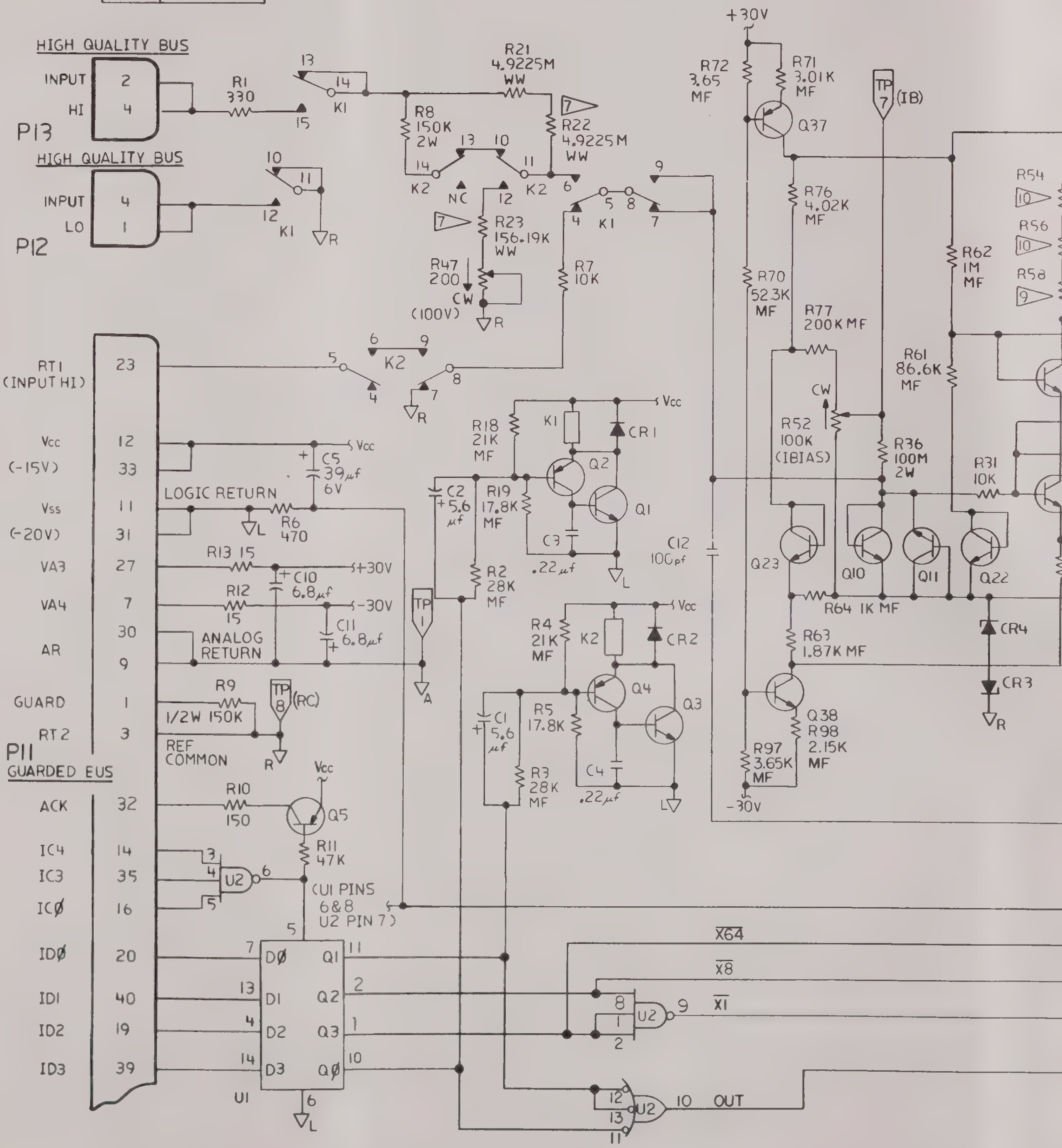

TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
C19
U5
R52
R53
R55
R54
R51
R50
R49
R48
R47
R24
R26
C18
U6
R77
R76
R75
R74
R73
R72
R71
R70
CR3
CR4
U3
C16
R57
R56
R58
R59
R25
R23
R99
R98
R97
Q13
C15
R64
R63
R62
R61
Q23
U4
R32
R33
C13
R95
R94
R93
R92
R91
R90
R89
R88
R87
Q39
Q37
Q22
R30
C14
Q18
Q13
R31
R34
Q36
Q35
Q34
Q33
Q32
Q31
Q16
Q15
Q14
R35
Q12
Q11
R36

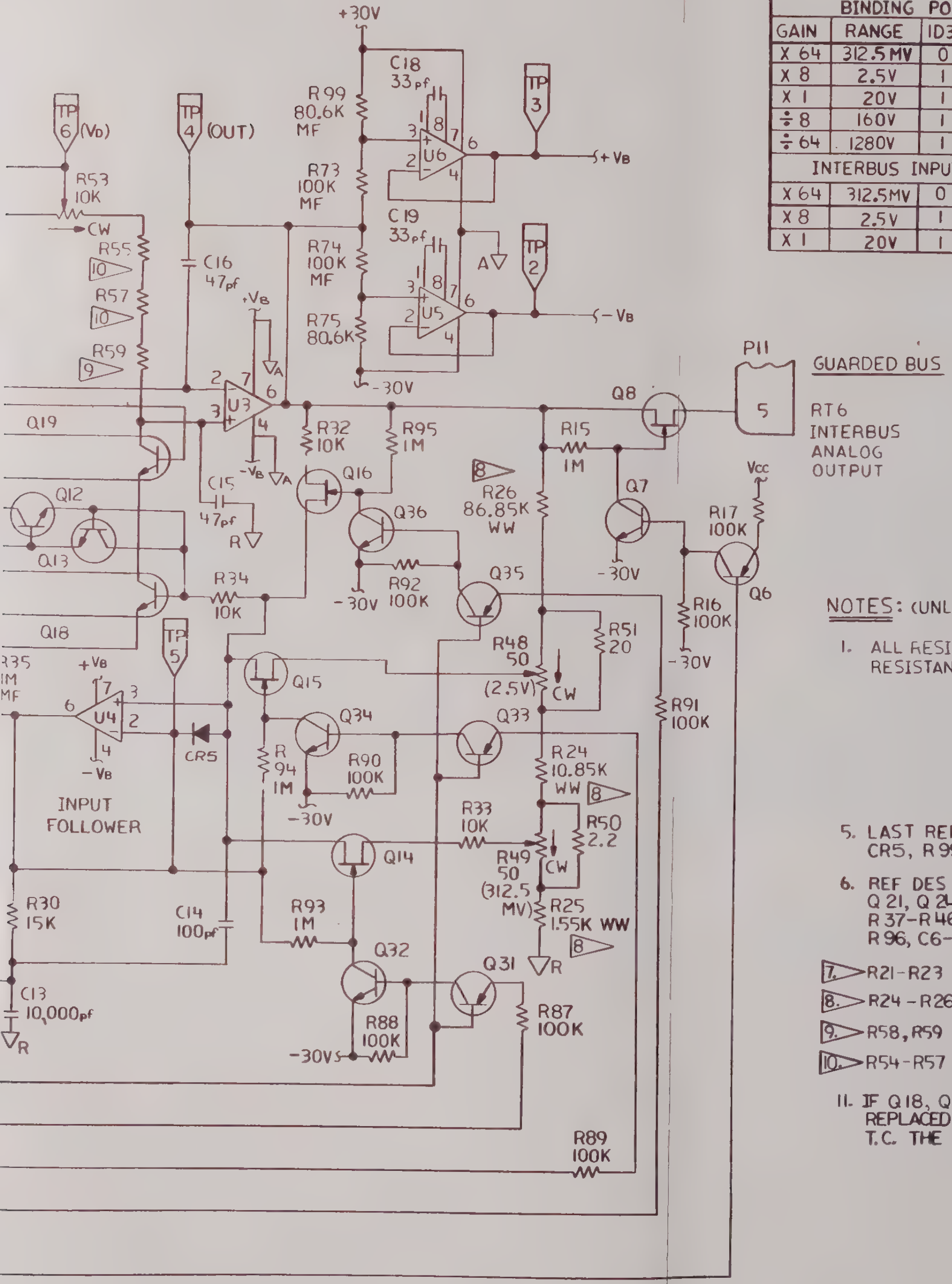

R8
R7
22
R21
CR1
CR2
R4
R18
K2
Q4
Q2
R3
R2
R5
R19
K1
R17
R16
R15
Q3
C4
Q1
C3
C10
C11
+
+
Q8
R9
Q7
Q6
Q5
U2
U1
C2
C1
+
+
R3
R12
R11
R10
R6
C5
+
R1

MIS-1700

Figure 8-11. A8 DC Signal Conditioner PCB Assembly

IC	Vcc (PIN)
U1	16
U2	14


HIGH QUALITY BUS
INPUT 2
HI 4
P13
HIGH QUALITY BUS
INPUT 4
LO 1
P12
R1 330
K1
R21 4.9225M WW
R8 150K 2W
R22 4.9225M WW
K2
NC
R23 156.19K WW
R47 200 CW (100V)
R7 10K
R
+30V
R72 3.65 MF
R71 3.01K MF
TP 7 (IB)
Q37
R76 4.02K MF
R70 52.3K MF
R77 200K MF
R52 100K (IBIAS)
CW
R36 100M 2W
R62 1M MF
R61 86.6K MF
R31 10K
R54
R56
R58
Q23
Q10
Q11
Q22
R64 1K MF
R63 1.87K MF
CR4
CR3
Q38
R98 2.15K MF
R97 3.65K MF
-30V
RT1 (INPUT HI) 23
Vcc 12
(-15V) 33
Vss 11
(-20V) 31
VA3 27
VA4 7
30
AR 9
GUARD 1
RT2 3
P11
GUARDED BUS
ACK 32
IC4 14
IC3 35
IC0 16
ID0 20
ID1 40
ID2 19
ID3 39
C5 39µf 6V
LOGIC RETURN
R6 470
R13 15
C10 6.8µf
+30V
R12 15
-30V
C11 6.8µf
ANALOG RETURN
TP 1
A
R9 1/2W 150K
TP 8 (RC)
REF COMMON
R10 150
Q5
R11 47K
U2
(U1 PINS 6&8 U2 PIN 7)
U1
D0 Q1
D1 Q2
D2 Q3
D3 Q0
L
K1
CR1
R18 21K MF
Q2
Q1
C2 5.6µf
R19 17.8K MF
C3 .22µf
R2 28K MF
C12 100pf
R4 21K MF
K2
CR2
Q4
Q3
C1 5.6µf
R5 17.8K
C4 .22µf
R3 28K MF
Vcc
X64
X8
X1
10 OUT


+30V
C18
33pf
R99
80.6K
MF
TP 3
TP 6 (VD)
TP 4 (OUT)
U6
+VB
R73
100K
MF
R53
10K
CW
C19
33pf
A
TP 2
R55
10
R74
100K
MF
C16
47pf
U5
-VB
R57
10
R75
80.6K
+VB
R59
9
-30V
U3
P11
GUARDED BUS
Q19
Q8
5
RT6
INTERBUS
ANALOG
OUTPUT
R32
10K
R95
1M
R15
1M
-VB
C15
47pf
Q16
R26
86.85K
WW
8
Vcc
Q12
Q7
Q36
R17
100K
R
Q13
R92
100K
-30V
R34
10K
Q35
Q6
R16
100K
TP 5
R51
20
Q18
R48
50
(2.5V)
CW
-30V
R35
1M
MF
+VB
Q15
R91
100K
U4
Q34
Q33
CR5
-VB
R94
1M
R90
100K
R24
10.85K
WW
8
INPUT
FOLLOWER
-30V
R33
10K
R50
2.2
Q14
R49
50
(312.5
MV)
CW
R30
15K
C14
100pf
R93
1M
R25
1.55K WW
8
Q32
Q31
R
C13
10,000pf
R
R88
100K
R87
100K
-30V
R89
100K

BINDING POST INPUT					
GAIN	RANGE	ID3	ID2	ID1	ID0
X 64	312.5 MV	0	1	1	0
X 8	2.5V	1	0	1	0
X 1	20V	1	1	1	0
÷ 8	160V	1	0	0	0
÷ 64	1280V	1	1	0	0
INTERBUS INPUT (RT2)					
X 64	312.5MV	0	1	0	1
X 8	2.5V	1	0	0	1
X 1	20V	1	1	0	1

NOTES: (UNLESS OTHERWISE NOTED)

1. ALL RESISTORS 1/4 W, CC, AND ALL RESISTANCE IN OHMS.

5. LAST REF DES NO'S USED: U6, Q38 CR5, R99, C21.

6. REF DES NO'S NOT USED: Q9, Q17, Q20, Q21, Q24-Q30, R14, R20, R27-R29, R37-R46, R60, R65-R69, R78-R86, R96, C6-C9, C17.

7. R21-R23 INPUT DIVIDER RESISTOR SET.

8. R24-R26 DC RANGE RESISTOR SET.

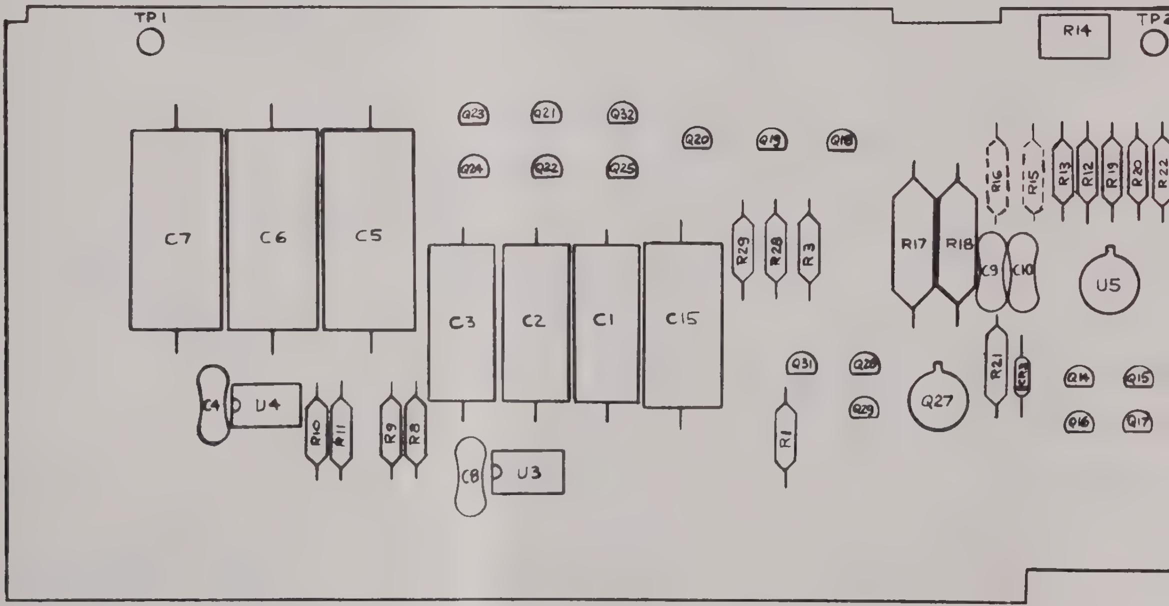
9. R58, R59 MATCHED RESISTOR SET.

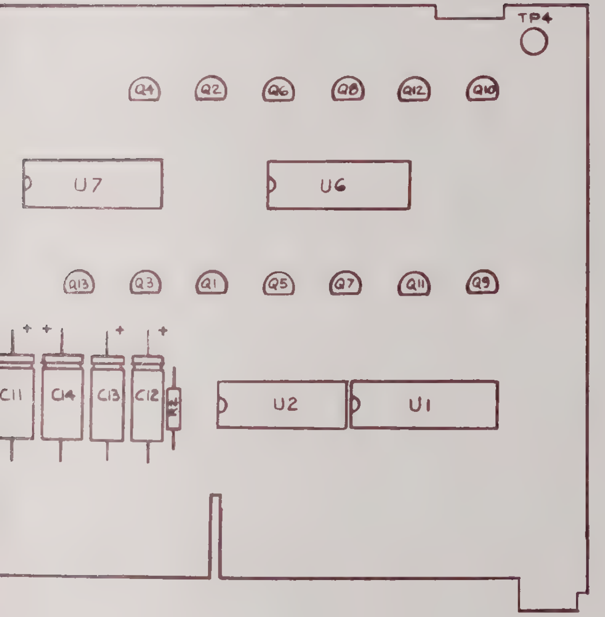
10. R54-R57 FACTORY SELECTED PARTS.

11. IF Q18, Q19, Q22, R54 OR R55 ARE REPLACED IT WILL BE NECESSARY TO T.C. THE MODULE

MIS 1100

Figure 8-11. A8 DC Signal Conditioner PCB Assembly (cont)


TP1
TP
R14
Q23
Q21
Q32
Q24
Q22
Q25
Q20
Q19
Q18
R16
R15
R13
R12
R19
R20
R22
C7
C6
C5
C3
C2
C1
C15
R29
R28
R3
R17
R18
C9
C10
U5
Q31
Q28
Q29
Q27
R21
Q14
Q15
Q16
Q17
C4
U4
R10
R11
R9
R8
C8
U3
R1

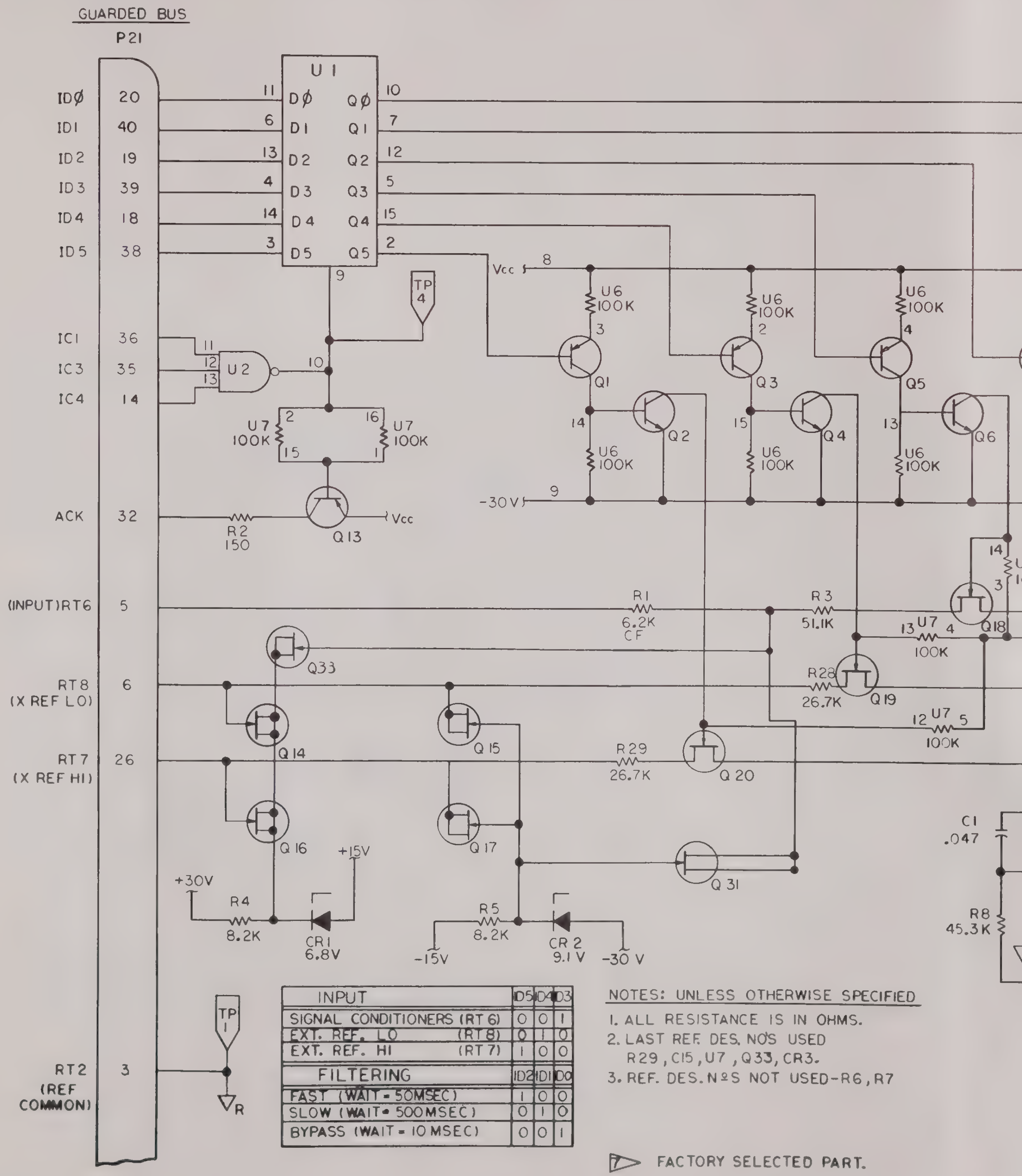

TP4
Q4
Q2
Q6
Q8
Q12
Q10
U7
U6
Q13
Q3
Q1
Q5
Q7
Q11
Q9
+
+
+
+
C11
C14
C13
C12
U2
U1

NOTES:

4. R15 & R16 WILL BE SELECTED DURING TEST.

MIS-1730

Figure 8-12. A9 Active Filter PCB Assembly


GUARDED BUS
P21
IDØ 20
ID1 40
ID2 19
ID3 39
ID4 18
ID5 38
IC1 36
IC3 35
IC4 14
ACK 32
(INPUT) RT6 5
RT8 (X REF LO) 6
RT7 (X REF HI) 26
RT2 (REF COMMON) 3
U1
DØ QØ
D1 Q1
D2 Q2
D3 Q3
D4 Q4
D5 Q5
11 6 13 4 14 3
10 7 12 5 15 2
9
TP 4
TP 1
U2
11 12 13
10
U7 100K
U7 100K
2 16 15 1
R2 150
Q13
Vcc
Vcc 8
-30V 9
U6 100K
3 2 4
14 15 13
Q1 Q2 Q3 Q4 Q5 Q6
R1 6.2K CF
R3 51.1K
U7 100K 13 4
U7 100K 12 5
14 3
Q18
R28 26.7K
Q19
Q33
Q14
Q15
Q16
Q17
R29 26.7K
Q20
Q31
+30V
R4 8.2K
CR1 6.8V
+15V
R5 8.2K
-15V
CR2 9.1V
-30V
C1 .047
R8 45.3K
R

INPUT	ID5	ID4	ID3
SIGNAL CONDITIONERS (RT 6)	0	0	1
EXT. REF. LO (RT8)	0	1	0
EXT. REF. HI (RT 7)	1	0	0
FILTERING	**ID2**	**ID1**	**ID0**
FAST (WAIT = 50MSEC)	1	0	0
SLOW (WAIT = 500MSEC)	0	1	0
BYPASS (WAIT = 10 MSEC)	0	0	1

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS.
2. LAST REF. DES. NO'S USED R29, C15, U7, Q33, CR3.
3. REF. DES. Nº S NOT USED-R6, R7

▷ FACTORY SELECTED PART.

U Nº	Vcc	∇_L
1	1,16	8
2	14	2,3,4,5,7

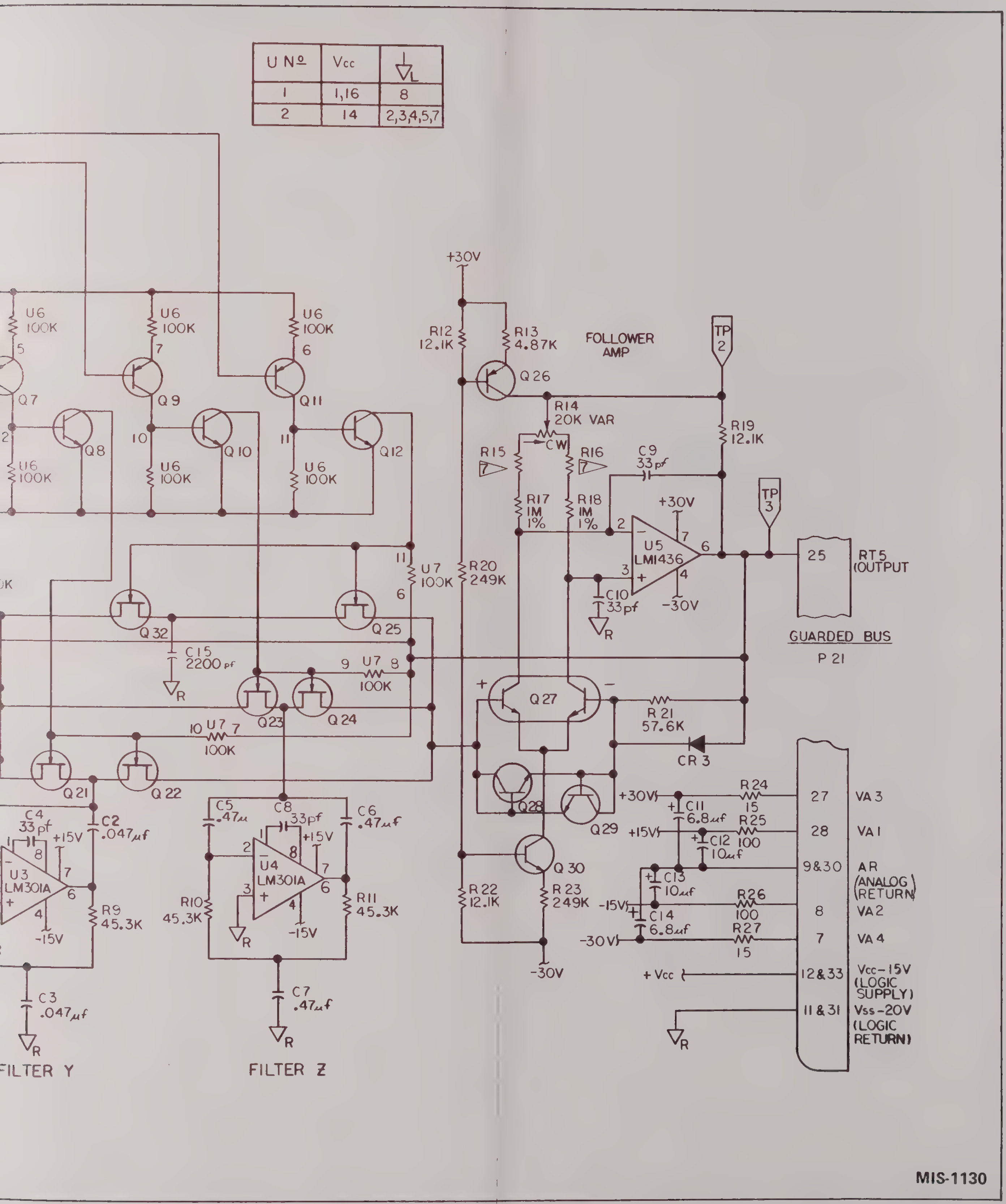
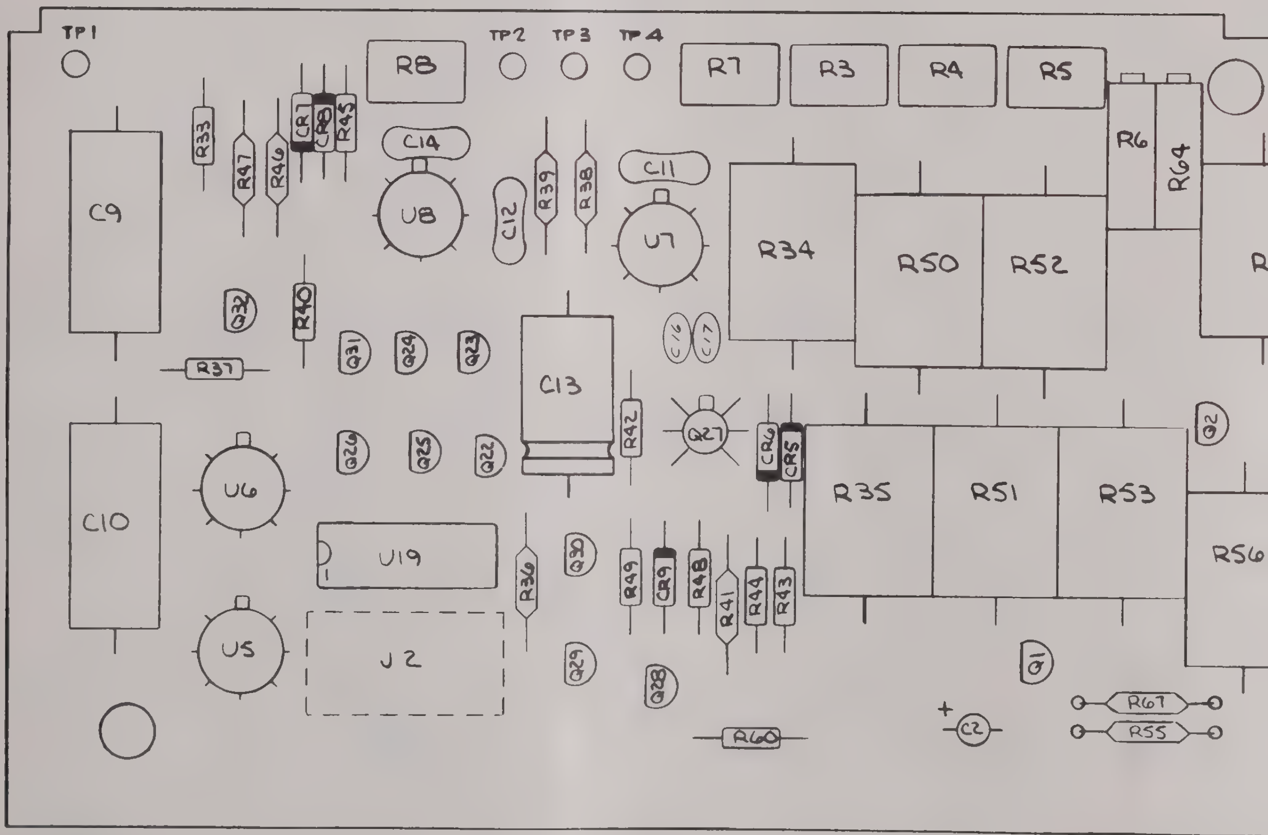

U6 100K
5
Q7
Q8
U6 100K
7
Q9
10
U6 100K
Q10
U6 100K
6
Q11
11
U6 100K
Q12
U7 100K
11
6
Q32
Q25
C15 2200 pf
R
9 U7 8 100K
Q23
Q24
10 U7 7 100K
Q21
Q22
C4 33pf
+15V
8
7
U3 LM301A
6
4
-15V
C2 .047μf
R9 45.3K
C3 .047μf
R
FILTER Y
C5 .47μ
C8 33pf
C6 .47μf
+15V
2
8
U4 LM301A
3
7
6
4
-15V
R10 45.3K
R11 45.3K
R
C7 .47μf
R
FILTER Z
+30V
R12 12.1K
R13 4.87K
Q26
FOLLOWER AMP
TP 2
R14 20K VAR
CW
R15 7
R16 7
R19 12.1K
C9 33pf
R17 1M 1%
R18 1M 1%
+30V
2
7
U5 LM1436
6
3
4
C10 33pf
R
-30V
TP 3
25
RT5 (OUTPUT)
GUARDED BUS
P 21
R20 249K
Q27
+
-
R21 57.6K
CR3
Q28
Q29
Q30
R22 12.1K
R23 249K
-30V
+30V
C11 6.8μf
R24 15
R25 100
+15V
C12 10μf
C13 10μf
-15V
C14 6.8μf
R26 100
R27 15
-30V
27 VA 3
28 VA 1
9&30 AR (ANALOG RETURN)
8 VA 2
7 VA 4
+ Vcc
12&33 Vcc-15V (LOGIC SUPPLY)
11&31 Vss-20V (LOGIC RETURN)
R
MIS-1130

Figure 8-12. A9 Active Filter PCB Assembly (cont)


TP1
R8
TP2
TP3
TP4
R7
R3
R4
R5
R33
R47
R46
CR7
CR8
R45
C14
U8
C12
R39
R38
C11
U7
R6
R64
C9
R34
R50
R52
Q32
R40
R37
Q31
Q24
Q23
C16
C17
C13
R42
Q27
CR6
CR5
Q2
Q26
Q25
Q22
U6
C10
R35
R51
R53
R56
U19
1
R36
Q30
R49
CR9
R48
R41
R44
R43
U5
J2
Q29
Q28
Q1
+
C2
R60
R67
R55

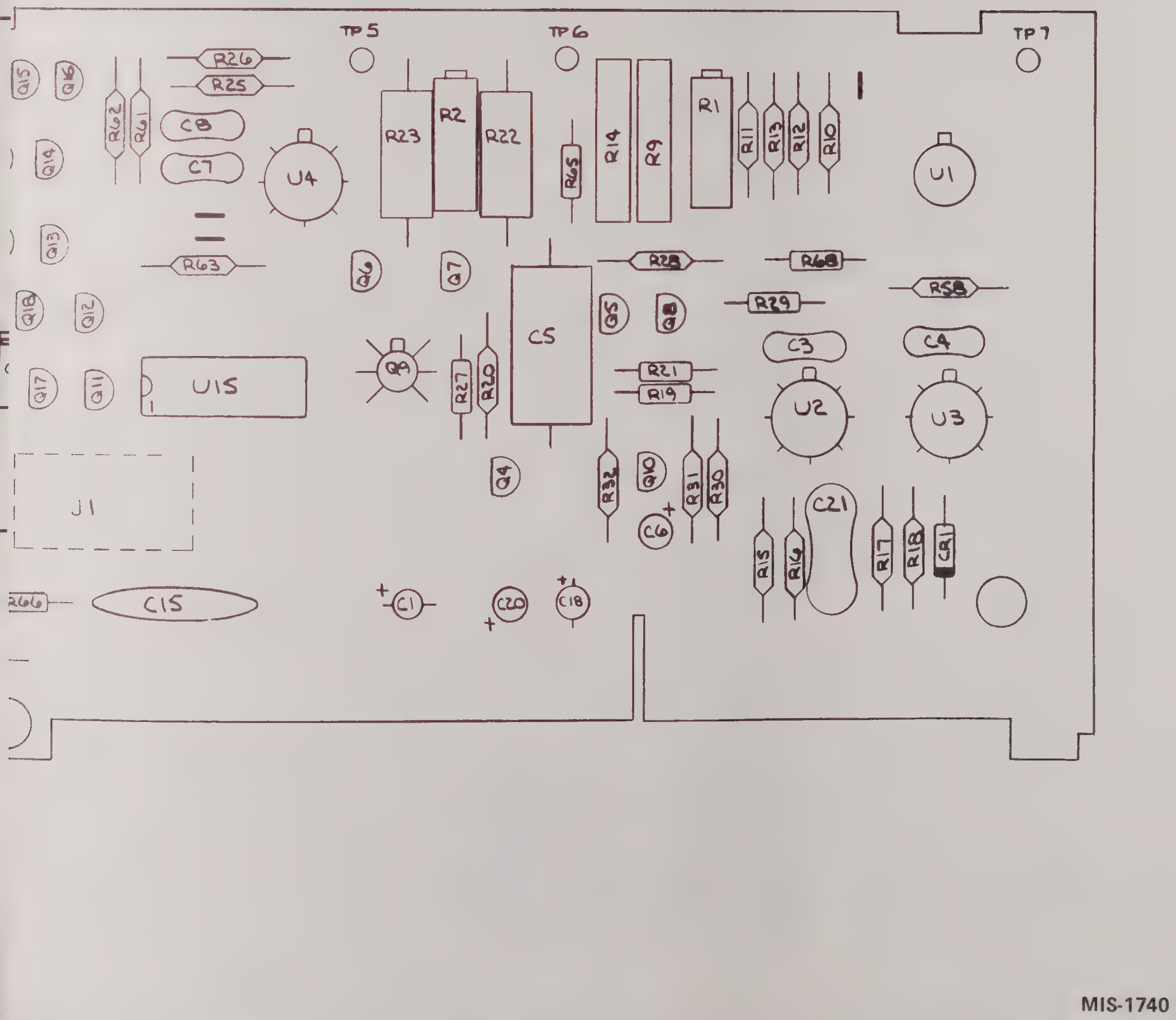
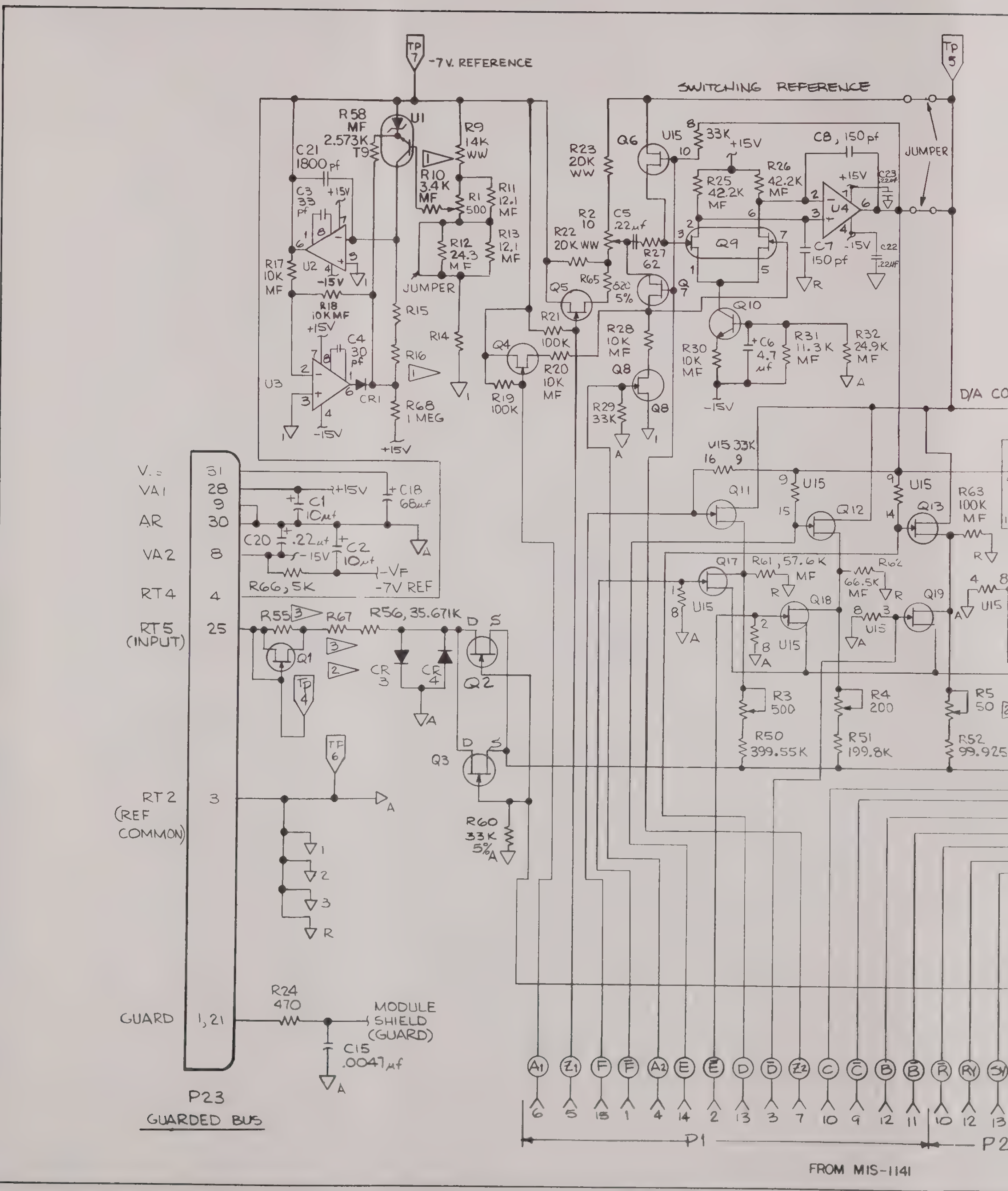
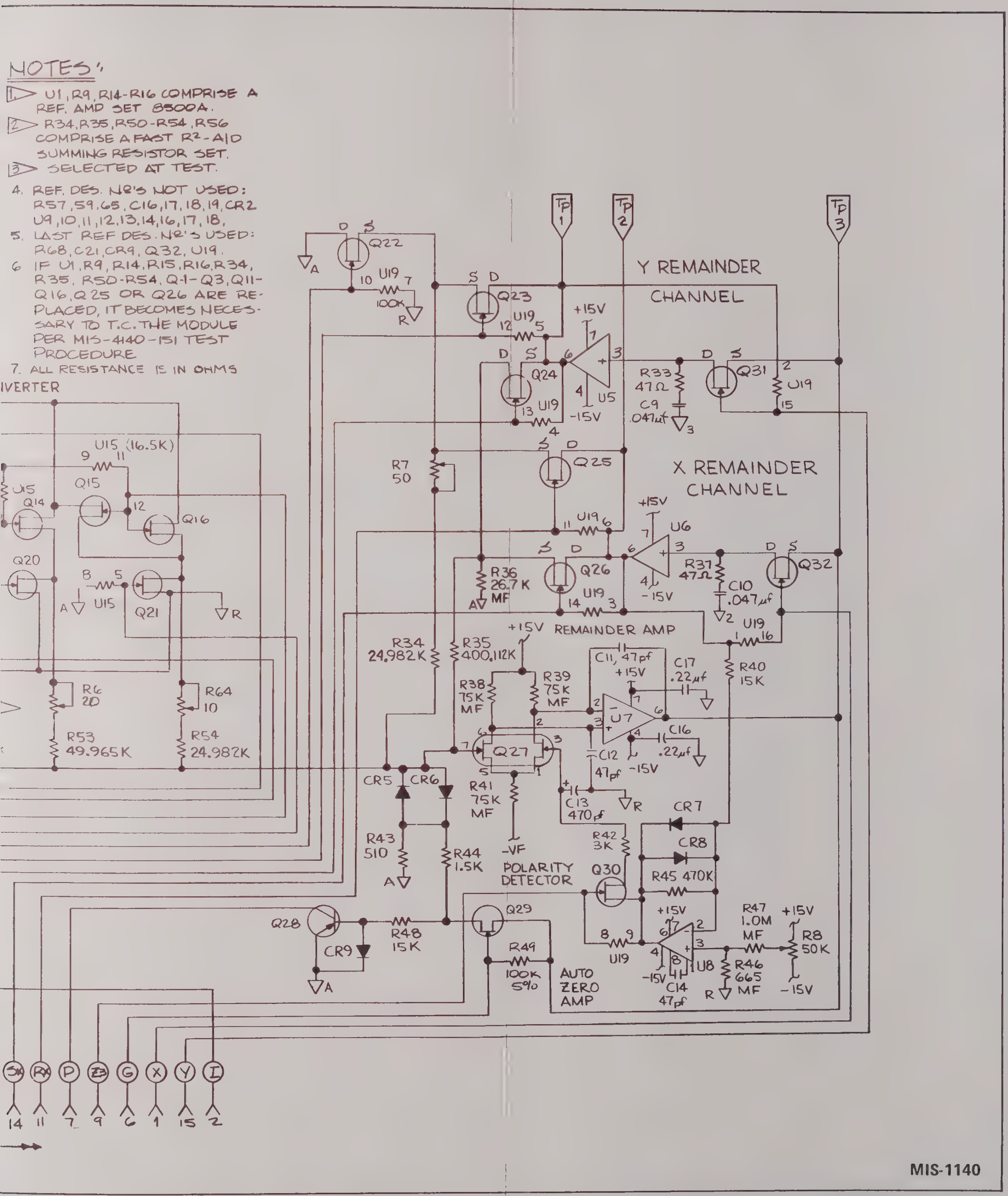

TP5
TP6
TP7
Q15
Q16
R26
R25
R62
R61
C8
C7
Q14
U4
R23
R2
R22
R65
R14
R9
R1
R11
R13
R12
R10
U1
Q13
R63
Q6
Q7
R28
R68
R58
R29
Q18
Q12
Q5
Q8
C5
C3
C4
Q9
R27
R20
R21
R19
U2
U3
Q17
Q11
U15
1
Q4
R32
Q10
R31
R30
C6
C21
J1
R15
R16
R17
R18
CR1
R66
C15
C1
C20
C18
MIS-1740

Figure 8-13. A10A1 Analog Display PCB Assembly


TP 7
-7V. REFERENCE
SWITCHING REFERENCE
TP 5
R58 MF 2.573K
T9
U1
R9 14K WW
R10 3.4K MF
R1 500
R11 12.1 MF
R12 24.3 MF
R13 12.1 MF
JUMPER
R14
R15
R16
R68 1 MEG
+15V
C21 1800 pf
C3 33 pf
+15V
U2
-15V
R17 10K MF
R18 10K MF
C4 30 pf
U3
CR1
-15V
R23 20K WW
Q6
U15
33K
R26 42.2K MF
R25 42.2K MF
C8, 150 pf
U4
C23 .22uf
C22 .22uf
-15V
JUMPER
R2 10
C5 .22uf
R22 20K WW
R27 62
Q9
C7 150 pf
R65 820 5%
Q5
Q7
Q10
R21 100K
Q4
R20 10K MF
R19 100K
R28 10K MF
Q8
R29 33K
R30 10K MF
C6 4.7 uf
R31 11.3K MF
R32 24.9K MF
-15V
D/A CO
U15 33K
Q11
Q12
Q13
R63 100K MF
Q17
R61, 57.6K MF
R62 66.5K MF
Q18
Q19
U15
R3 500
R50 399.55K
R4 200
R51 199.8K
R5 50
R52 99.925
V.=
VA1
AR
VA2
RT4
RT5 (INPUT)
RT2 (REF COMMON)
GUARD
31
28
9
30
8
4
25
3
1, 21
C1 10uf
C18 68uf
C20 .22uf
C2 10uf
-15V
-VF
R66, 5K
-7V REF
R55
R67
R56, 35.671K
Q1
TP 4
CR 3
CR 4
Q2
Q3
D
S
TP 6
R60 33K 5%
R24 470
MODULE SHIELD (GUARD)
C15 .0047uf
P23
GUARDED BUS
A1 Z1 F F̄ A2 E Ē D D̄ Z2 C C̄ B B̄ R RY
6 5 15 1 4 14 2 13 3 7 10 9 12 11 10 12 13
P1
P2
FROM MIS-1141

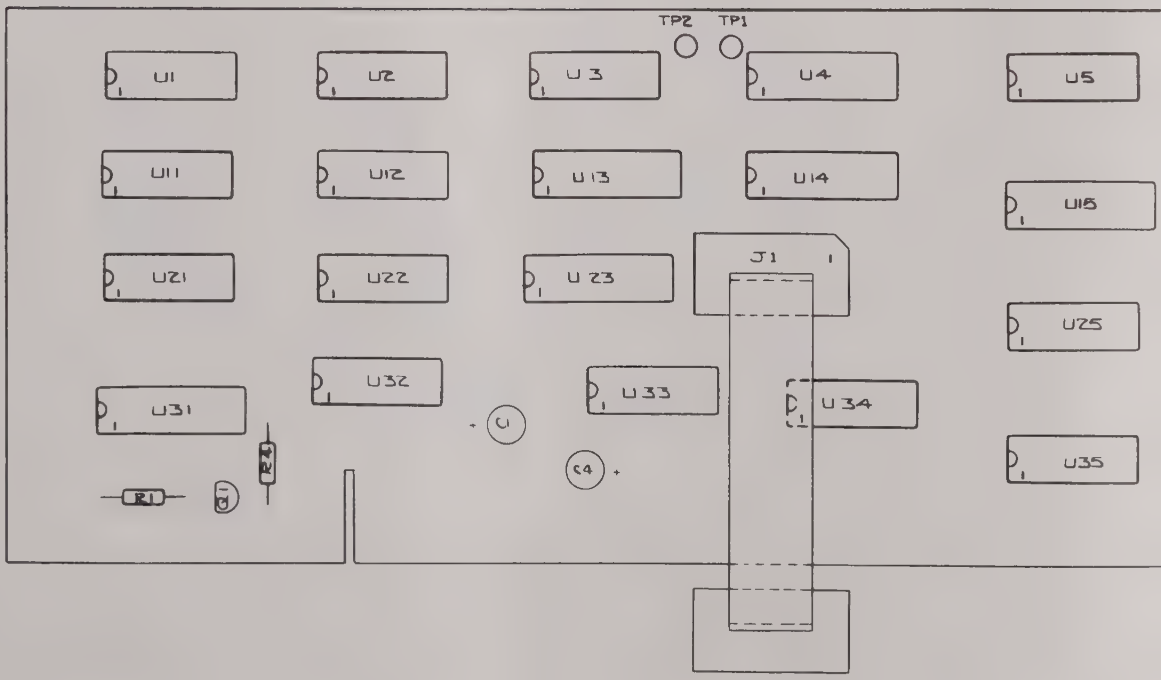


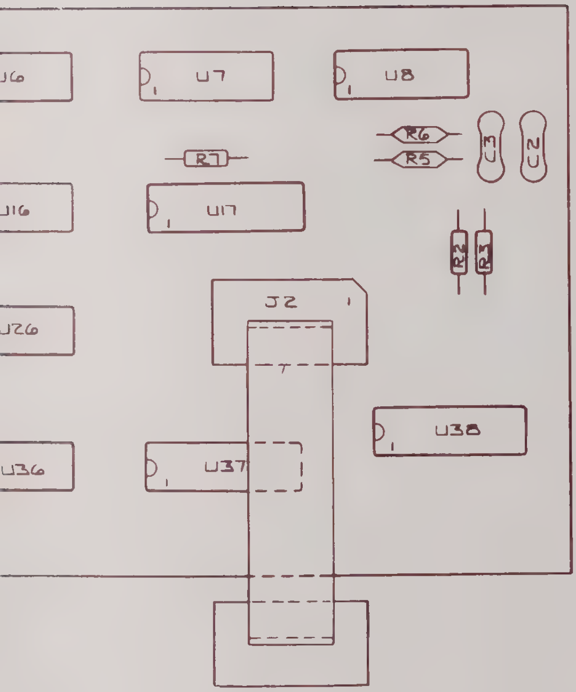
NOTES:

1. U1, R9, R14-R16 COMPRISE A REF. AMP SET 8500A.
2. R34, R35, R50-R54, R56 COMPRISE A FAST R^2-A/D SUMMING RESISTOR SET.
3. SELECTED AT TEST.
4. REF. DES. NO'S NOT USED: R57, 59, 65, C16, 17, 18, 19, CR2 U9, 10, 11, 12, 13, 14, 16, 17, 18,
5. LAST REF DES. NO'S USED: R68, C21, CR9, Q32, U19.
6. IF U1, R9, R14, R15, R16, R34, R35, R50-R54, Q1-Q3, Q11-Q16, Q25 OR Q26 ARE REPLACED, IT BECOMES NECESSARY TO T.C. THE MODULE PER MIS-4140-151 TEST PROCEDURE
7. ALL RESISTANCE IS IN OHMS

IVERTER
Y REMAINDER CHANNEL
X REMAINDER CHANNEL
REMAINDER AMP
POLARITY DETECTOR
AUTO ZERO AMP
TP 1
TP 2
TP 3
Q22
Q23
Q24
Q25
Q26
Q27
Q28
Q29
Q30
Q31
Q32
Q14
Q15
Q16
Q20
Q21
U5
U6
U7
U8
U19
U15 (16.5K)
R7 50
R33 47Ω
C9 .047µf
R36 26.7K MF
R37 47Ω
C10 .047µf
R34 24.982K
R35 400.112K
R38 75K MF
R39 75K MF
R40 15K
C11, 47pf
C17 .22µf
C16 .22µf
C12 47pf
C13 470pf
R41 75K MF
R42 3K
R43 510
R44 1.5K
R45 470K
R46 665 MF
R47 1.0M MF
R48 15K
R49 100K 5%
R8 50K
C14 47pf
R6 20
R64 10
R53 49.965K
R54 24.982K
CR5
CR6
CR7
CR8
CR9
+15V
-15V
-VF
SX
RX
P
Z3
G
X
Y
I
14
11
7
9
6
1
15
2
MIS-1140

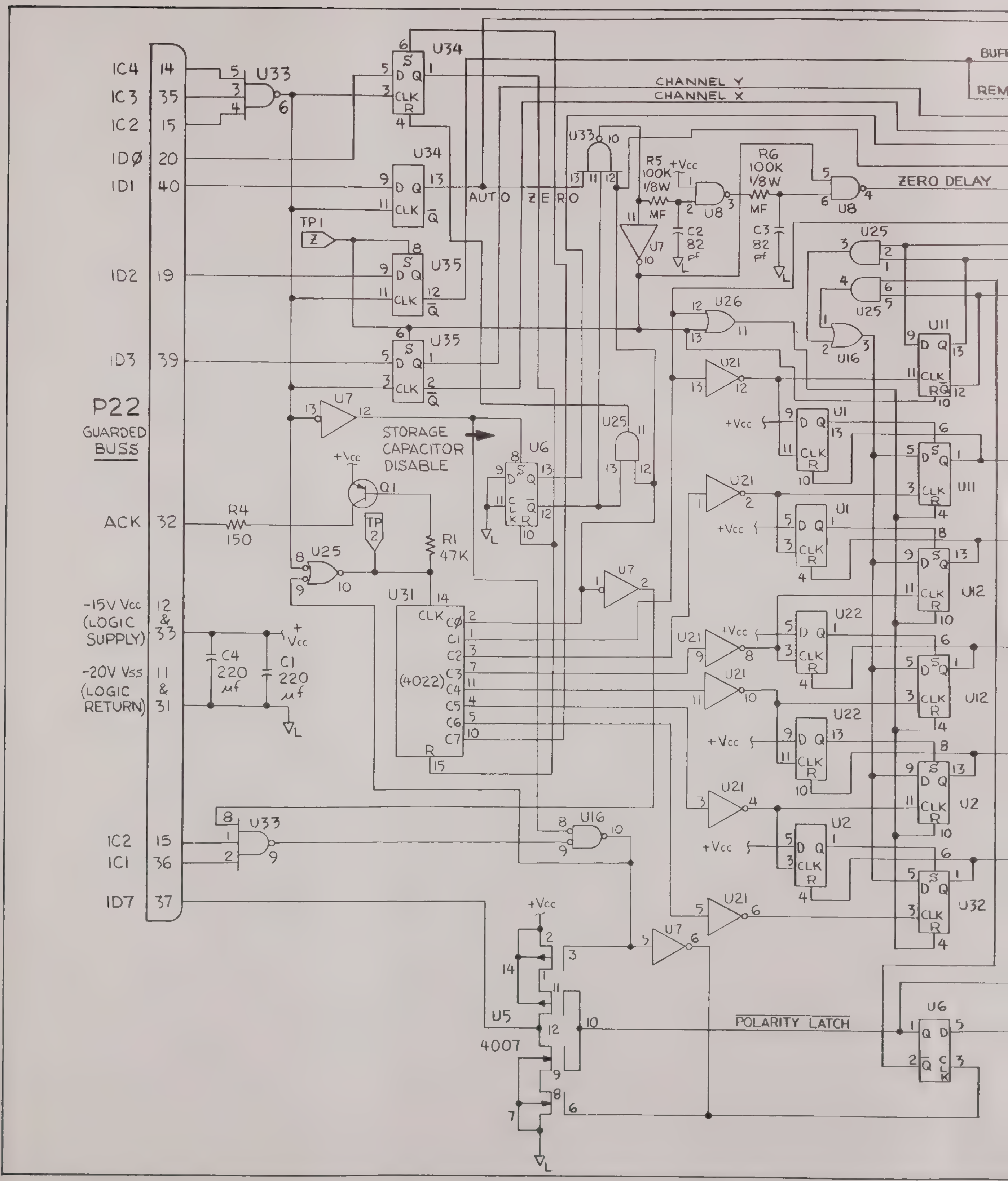
Figure 8-13. A10A1 Analog Display PCB Assembly (cont)

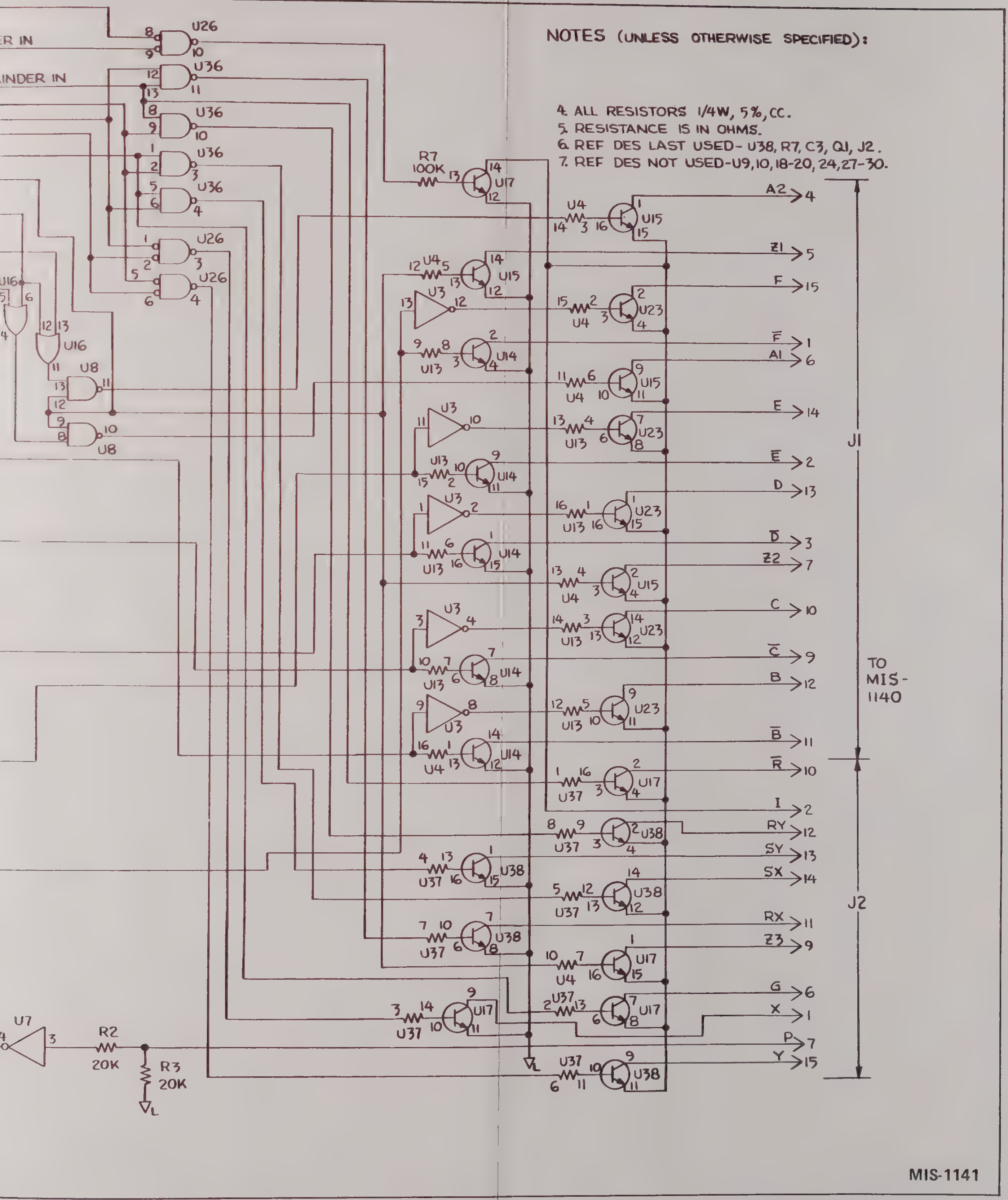

TP2
TP1
U1
U2
U3
U4
U5
U11
U12
U13
U14
U15
J1
U21
U22
U23
U25
U31
U32
U33
U34
U35
C1
C4
R1
R2
Q1


U7
U8
R6
R5
C3
C2
R7
U17
R2
R3
J2
U38
U36
U37
1

MIS-1741

Figure 8-14. A10A2 Fast RR A/D Converter
Digital PCB Assembly


P22
GUARDED BUSS
IC4 14
IC3 35
IC2 15
IDØ 20
ID1 40
ID2 19
ID3 39
ACK 32
-15V Vcc (LOGIC SUPPLY) 12 & 33
-20V Vss (LOGIC RETURN) 11 & 31
IC2 15
IC1 36
ID7 37
U33
U34
U35
U7
U25
U6
U31
(4022)
CLK
CØ
C1
C2
C3
C4
C5
C6
C7
R
Q1
R4 150
R1 47K
TP1
TP 2
C4 220 µf
C1 220 µf
+Vcc
STORAGE CAPACITOR DISABLE
AUTO ZERO
CHANNEL Y
CHANNEL X
R5 100K 1/8W MF
C2 82 pf
R6 100K 1/8W MF
C3 82 pf
U8
ZERO DELAY
U26
U21
U16
U11
U1
U12
U22
U2
U32
U5
4007
POLARITY LATCH
BUF
REM



NOTES (UNLESS OTHERWISE SPECIFIED):

4. ALL RESISTORS 1/4W, 5%, CC.
5. RESISTANCE IS IN OHMS.
6. REF DES LAST USED- U38, R7, C3, Q1, J2.
7. REF DES NOT USED-U9, 10, 18-20, 24, 27-30.

ER IN
INDER IN
U26
U36
U16
U8
U3
U4
U13
U14
U15
U17
U23
U37
U38
U7
R7
100K
R2
20K
R3
20K
A2 4
Z1 5
F 15
F̄ 1
A1 6
E 14
Ē 2
D 13
D̄ 3
Z2 7
C 10
C̄ 9
B 12
B̄ 11
R̄ 10
I 2
RY 12
SY 13
SX 14
RX 11
Z3 9
G 6
X 1
P 7
Y 15
J1
J2
TO MIS-1140
MIS-1141

Figure 8-14. A10A2 Fast FF A/D Converter Digital PCB Assembly (cont)

CHANGE/ERRATA INFORMATION

ISSUE NO: 1 1/83

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCB is equal to or higher than that given with each change.
2. No revision letter is indicated at the beginning of the change/errata.

MANUAL

Title: 8502A DIGITAL MULTIMETER
Print Date: MARCH 1978
Rev. and Date: 1 - JUL 81

C/E PAGE EFFECTIVITY

Page No.	Print Date
1	1/83
2	1/83
3	1/83
4	1/83
5	1/83
6	1/83
7	1/83

CHANGE #1 - 17341
Rev.-N, Final Assembly (8502A-5001)

On pages 3-2 thru 3-5, delete paragraphs 3-10 thru 3-19 and Figures 3-3, 3-4 and 3-5.

On pages 3-8 thru 3-12, delete paragraphs 3-34 thru 3-53 and Figures 3-9, 3-10, 3-11, 3-12, 3-13 and 3-14.

On page 4-18, delete Figure 4-6.

On page 5-3, Table 5-1:
CHANGE: A6¦CONTROLLER ASSY (8502A-4185T)¦384034¦89536¦384034¦1
TO: A6¦CONTROLLER ASSY (8502A-4187T)¦661694¦89536¦661694¦1

On page 5-11, replace Table 5-6 with Table 1.

On page 5-12, replace Figure 5-5 with Figure 1.

On pages 5-13 and 5-14, delete Table 5-7.

On page 5-15, replace Figure 5-6 with Figure 2.

On page 5-16, delete Table 5-8.

On page 5-17, delete Figure 5-7.

On page 8-1/8-2:
Change the NAME and DRAWING NO. for Figure 8-6,
FROM: A6A1 Controller PCB Assembly 8502A-1785T
TO: A6 Controller Assembly 8502A-1687T

Delete the entry for Figure 8-7.

On page 8-14, replace Figure 8-6 (8502A-1785) with Figure 2.

On pages 8-15/8-16 and 8-17, replace Figure 8-6 (8502A-1185) with Figure 3.

On pages 8-18 and 8-19, delete Figure 8-7.

Table 1.

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
A6	CONTROLLER PCB ASSEMBLY FIGURE 5-6 (8502A-4187T)	661694	89536	661694	REF		
C1	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	20		
C2	CAP, CER, 1800 PF +/-5%, 50V	528547	89536	528547	1		
C3	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C4	CAP, FILM, 6.8 UF +/-10%, 35V	182782	56289	150D687X0035	1		
C5	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C6	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C7	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C8	CAP, TA, 39 UF +/-20%, 6V	163915	56289	196D396X0006	1		
C9	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	1		
C10	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C11	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C12	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C13	CAP, MICA, 33 PF +/-5%, 500V	160317	02799	DM15E330J	1		
C14	CAP, CER, 2700 PF, GMV, 600V	106211	51406	DD60B1025U272P1KV	1		
C15	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C16	CAP, ELECT, 47 UF +75/-20%, 25V	655191	89536	655191	4		
C17	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C18	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C19	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C20	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C21	CAP, ELECT, 47 UF +75/-20%, 25V	655191	89536	655191	REF		
C22	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C23	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C24	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C25	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C26	CAP, ELECT, 47 UF +75/-20%, 25V	655191	89536	655191	REF		
C27	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C28	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
C29	CAP, ELECT, 47 UF +75/-20%, 25V	655191	89536	655191	REF		
C30	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CZ30C224M	REF		
CR1	DIODE, SI, HI SPEED SWITCHING	203323	07910	1N4448	1	1	
CR3	DIODE, ZEN, UNCOMP, 5.1 Vz	535476	04713	1N5231B	REF		
H1	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		
MP1	CASE ASSEMBLY, CONTROLLER	471326	89536	471326	1		1
MP2	CASE HALF	402990	89536	402990	2		
MP3	CASE COVER	402974	89536	402974	1		
MP4	SHIELD, CASE COVER	440008	89536	440008	1		
MP5	DECAL, "CONTROLLER"	453696	89536	453696	1		
MP6	DECAL, "CAUTION"	454504	89536	454504	1		
MP7	GUARD, CASE REAR	383364	89536	383364	1		
MP8	GUARD, CASE FRONT	383356	89536	383356	1		
MP9	SPRING, COIL, 6 - 3/4 (with H1)	424465	83553	C0102-014-0380M	1		
MP10	SPACER, STANDOFF, 4-40 (not shown)	335604	89536	335604	1		
R1	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	2		
R2	RES, DEP. CAR, 620K +/-5%, 1/4W	442509	80031	CR251-4-5P620K	1		

Table 1. (cont.)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
R3	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	3		
R4	RES, DEP. CAR, 1.5K +/-5%, 1/4W	343418	80031	CR251-4-5P1K5	3		
R5	RES, DEP. CAR, 1.5K +/-5%, 1/4W	343418	80031	CR251-4-5P1K5	REF		
R6	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R8	RES, DEP. CAR, 33K +/-5%, 1/4W	348888	80031	CR251-4-5P33K	1		
R9	RES, DEP. CAR, 1.5K +/-5%, 1/4W	343418	80031	CR251-4-5P1K5	REF		
R10	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R11	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
RN1	NETWORK, RESISTOR, SIP, 6.2K, 10-PIN	501536	91637	MSP10A01622G	3		
RN2	NETWORK, RESISTOR, SIP, 6.2, 10-PIN	501536	91637	MSP10A01622G	REF		
RN3	NETWORK, RESISTOR, SIP, 2K, 10-PIN	446880	91637	446880	1		
RN4	NETWORK, RESISTOR, SIP, 6.2K, 10-PIN	501536	91637	MSP10A01622G	REF		
TP1-TP7	TERMINAL, CONNECTOR	512889	02660	62395	7		
U1	IC, TTL LPS, DUAL J-K F/F	412999	01295	SN74LS109N	1	1	
U2	⊘ IC, CMOS, MONOSTABLE MV	454017	04713	MC14538BCP	1	1	
U3	⊘ IC, CMOS, DUAL UP COUNTER	355164	04713	MC14520BCP	1	1	
U4	⊘ IC, CMOS/MOS, PLL	403584	02735	CD4046AE	1	1	
U5	IC, LSTTL, QUAD 1-INPUT NAND GATE	393033	04713	SN74LS00N	1	1	
U6	IC, LSTTL, TRIPLE 3-INPUT & GATE	393082	07263	74LS11PC	1	1	
U7	⊘ IC, CMOS, DUAL D F/F W/SET & RESET	536433	04713	MC4013BCP	2	1	
U8	⊘ IC, CMOS, TRIPLE 3-INPUT NOR GATE	586453	04713	MC14025UBCP	2	1	
U9	⊘ IC, CMOS, DUAL D F/F/ W/SET & RESET	536433	04713	MC4013BCP	REF		
U10	⊘ IC, CMOS, HEX INVERTER	381848	02735	CD4049AE	1	1	
U11	⊘ IC, CMOS, TRI 3-INPUT NAND GATES	375147	02735	CD4023UBE	1	1	
U12	IC, LSTTL, QUAD & EDGE TRG D F/F CLR	393215	01295	SN74LS175N	1	1	
U13	IC, LSTTL, OCTL INV DRVR W/ENAB NOT	429480	01295	SN74LS240N	1	1	
U14	⊘ IC, CMOS, QUAD 2-INPUT NAND GATE	355198	04713	MC14011UBCP	1	1	
U15	⊘ IC, NMOS, 8080A, 8-BIT MICROPROCESSOR	404541	34649	C8080A	1	1	
U16	⊘ IC, CMOS, TRIPLE 3-INPUT NOR GATE	586453	04713	MC14025UBCP	REF		
U17	⊘ IC, CMOS, QUAD 2-INPUT NOR GATE	355172	02735	CD4001AE	2	1	
U18	IC, TTL MULTIPLEXER	393165	01295	SN74LS139N	1	1	
U19	IC, STTL, 8224/8080 CLOCK GENERATOR	586230	89536	586230	1		
U21	⊘ IC, CMOS, 8-BIT PRIORITY ENCODER	412973	02735	CD4532BE	1	1	
U22	⊘ IC, NMOS, 2KX8 BIT STATIC ROM	584144	89536	584144	1	1	
U23	IC, PROM, PROGRAMMED, 8502A-4505	661728	89536	661728	1		
U24	IC, PROM, PROGRAMMED, 8502A-4505	661736	89536	661736	1		
U25	⊘ IC, CMOS, OCT BUS TRNSCVR EQ TO L3245	535906	36665	MD74C245AC	1	1	
U26	⊘ IC, CMOS, QUAD 2-INPUT NOR GATE	355172	02735	CD4001AE	REF		
U27	⊘ IC, CMOS, QUAD 2-INPUT NAND GATE	404632	02735	CD4039BE	1	1	
XU15	SOCKET, IC, 40-PIN	429282	91506	340-AG39D	1		
XU19	SOCKET, IC, 16-PIN	276535	91506	316-AG39D	1		
XU20	SOCKET, IC, 24-PIN	376236	91506	324-AG39D	2		
XU22	SOCKET, IC, 24-PIN	376236	91506	324-AG39D	REF		
XU23	SOCKET, IC, 28-PIN	448217	91506	328-AG39D	2		
XU24	SOCKET, IC, 28-PIN	448217	91506	328-AG39D	REF		
Y1	CRYSTAL, QUARTZ	642728	89536	642728	1	1	

1 USE P/N 471326 TO ORDER COMPLETE MODULE CASE ASSY., WITHOUT PCB ASSY.

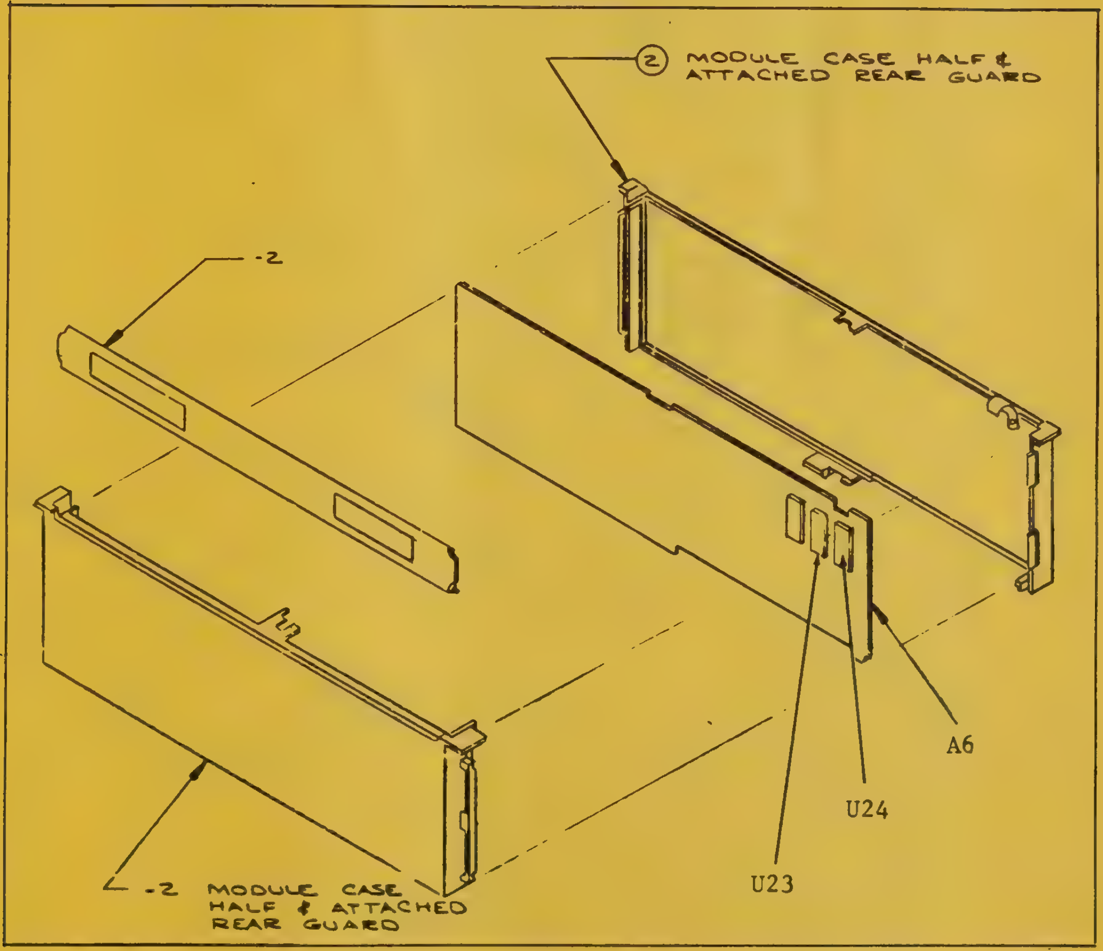

② MODULE CASE HALF & ATTACHED REAR GUARD
-2
A6
U24
U23
-2 MODULE CASE HALF & ATTACHED REAR GUARD

Figure 1.

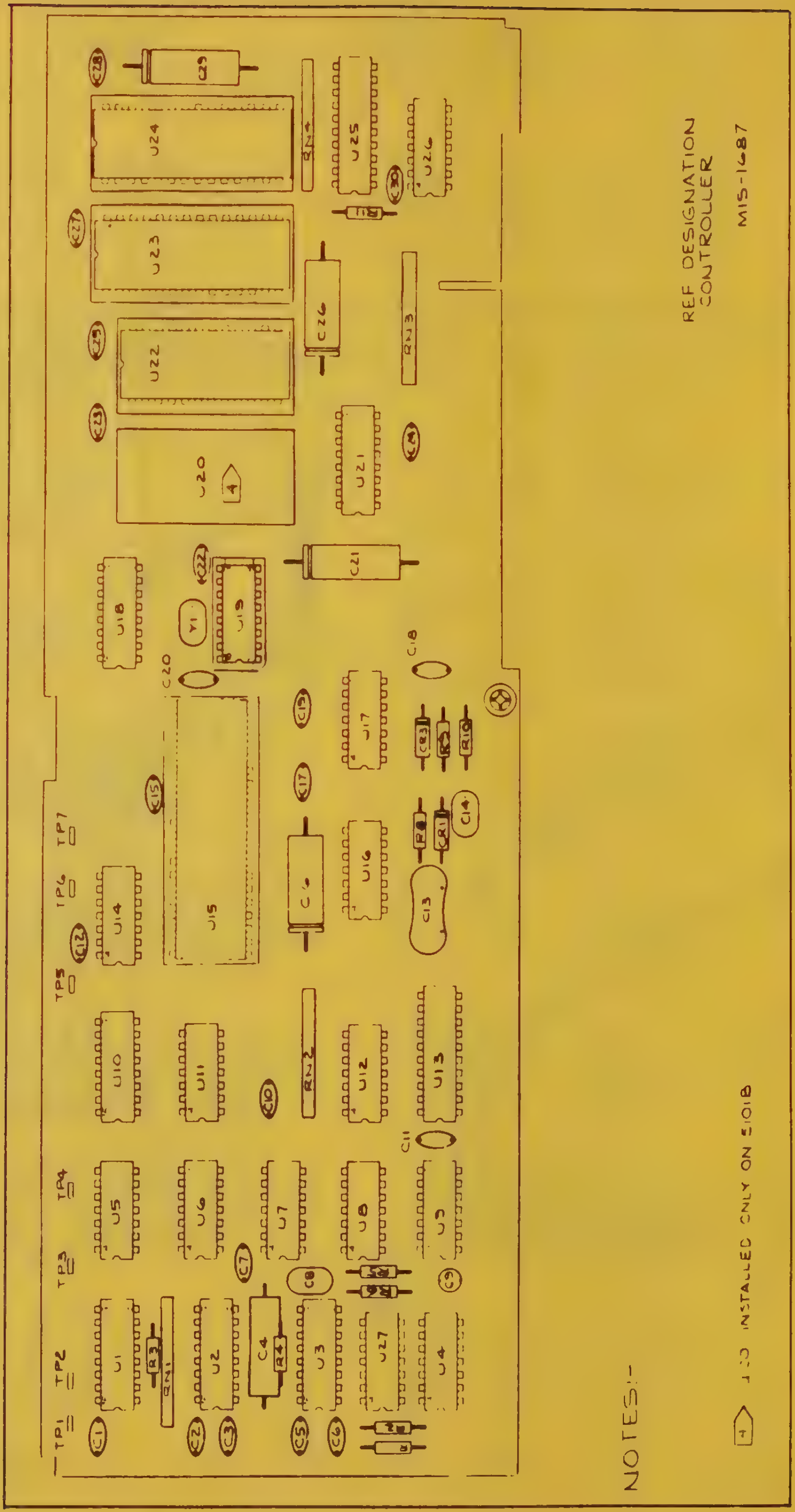

REF DESIGNATION
CONTROLLER
MIS-1687
NOTES:-
4 U20 INSTALLED ONLY ON 5101B
U1
U2
U3
U4
U5
U6
U7
U8
U9
U10
U11
U12
U13
U14
U15
U16
U17
U18
U19
U20
U21
U22
U23
U24
U25
U26
U27
Y1
RN1
RN2
RN3
RN4
R1
R3
R4
R8
R10
CR1
CR3
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C17
C18
C19
C20
C21
C22
C23
C24
C25
C26
C27
C28
C29
C30
TP1
TP2
TP3
TP4
TP5
TP6
TP7

Figure 2.

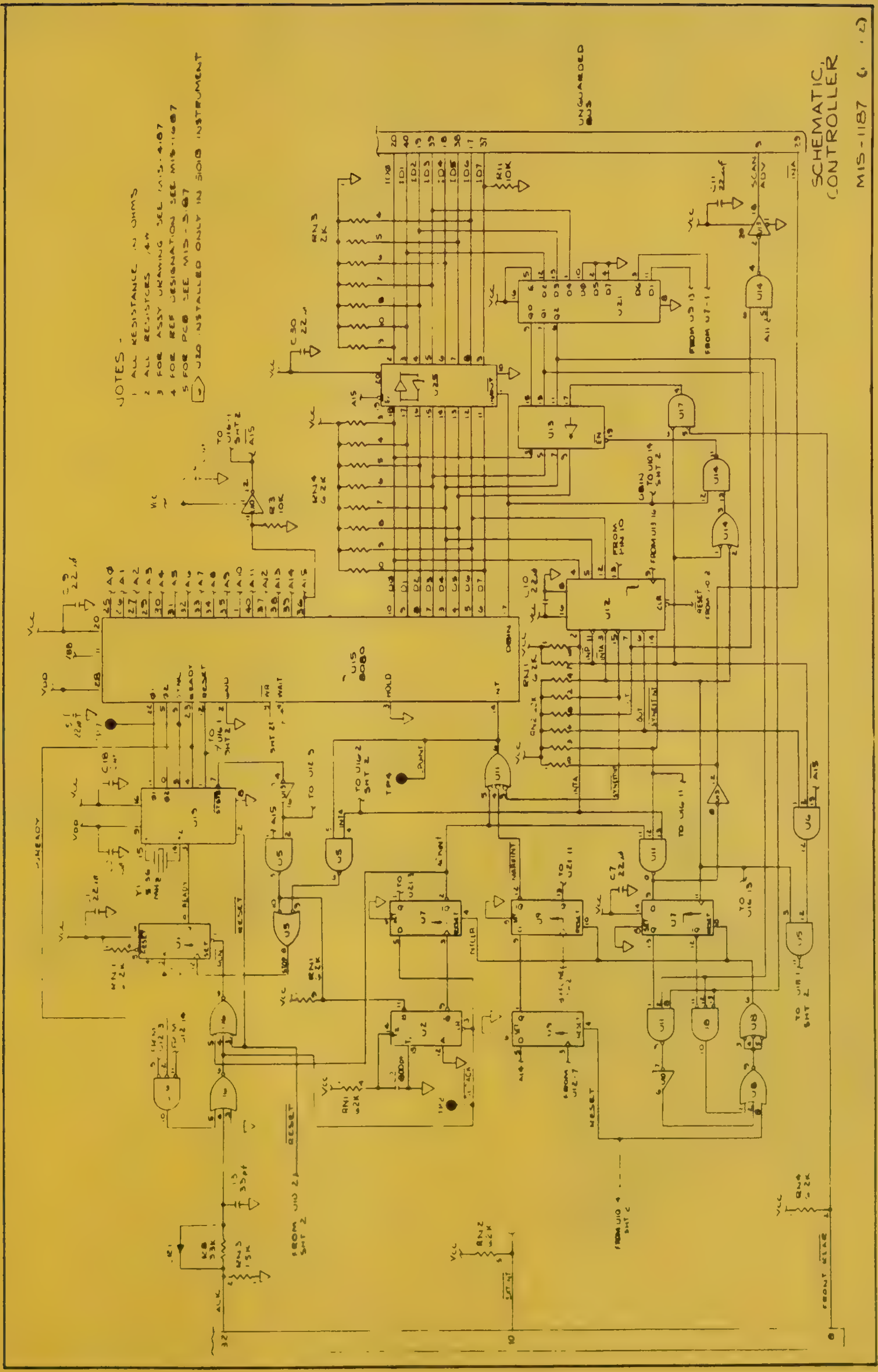

NOTES -
1 ALL RESISTANCE IN OHMS
2 ALL RESISTORS 1/4W
3 FOR ASSY DRAWING SEE MIS-4187
4 FOR REF DESIGNATION SEE MIS-1187
5 FOR PCB SEE MIS-3187
U20 INSTALLED ONLY IN 5108 INSTRUMENT
SCHEMATIC, CONTROLLER
MIS-1187
U15 8080
U25
U21
U13
U12
UNGUARDED BUS
SCAN ADV
HOLD
INT
DBIN
READY
RESET
WAIT
VCC
VDD
TP4
FROM U10 2 SHT 2
FRONT WAKE

Figure 3.

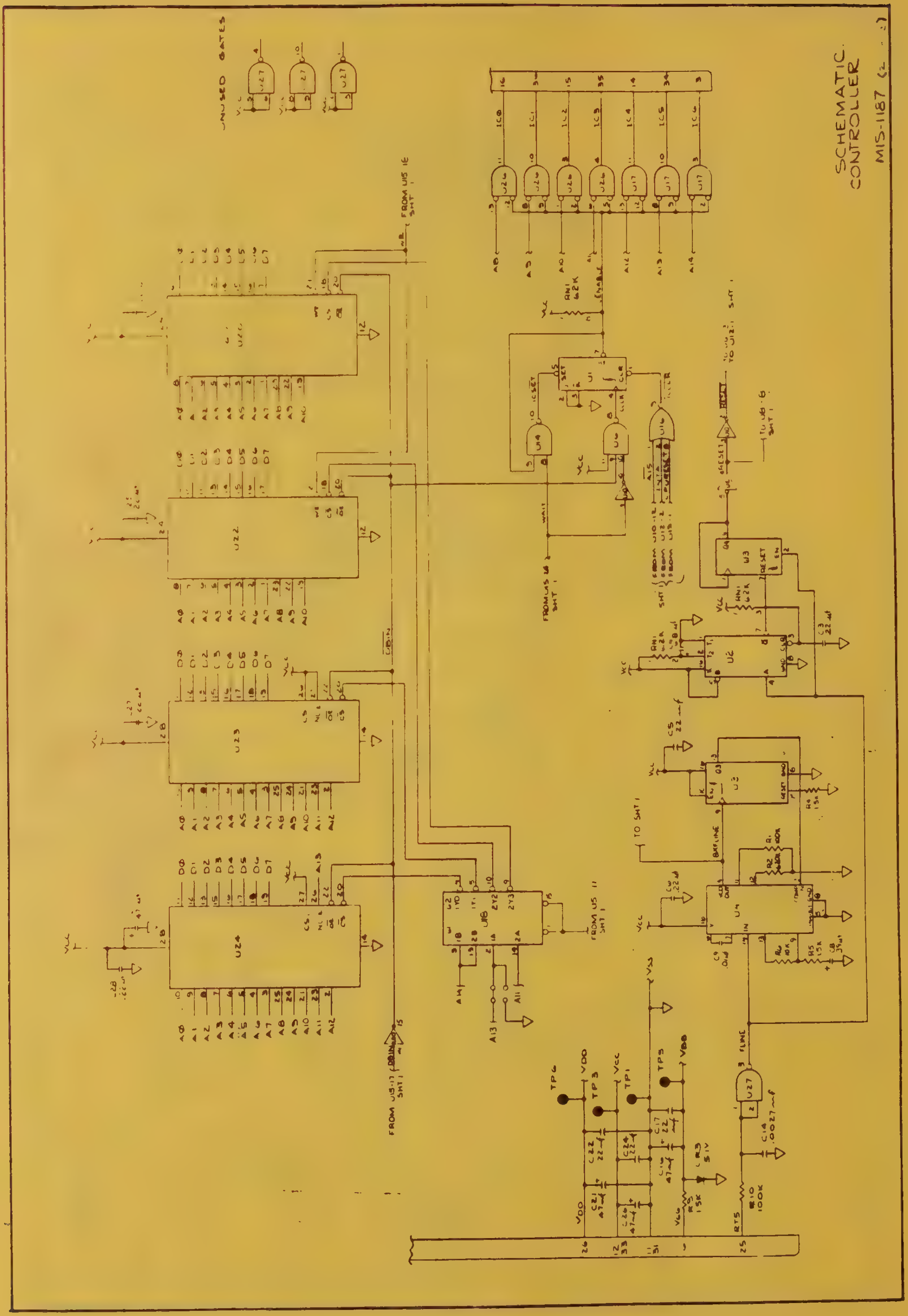

SCHEMATIC
CONTROLLER
MIS-1187 (2 . 2)
UNUSED GATES
U27
U26
U17
IC0
IC1
IC2
IC3
IC4
IC5
IC6
U21
U22
U23
U24
U16
U1
U3
U2
U4
U18
FROM U15 1E SHT 1
FROM U5 11 SHT 1
FROM U15-17 SHT 1
DBIN
ENABLE
WAIT
RESET
TO SHT 1
FLINE
RTS
VDD
VCC
VSS
TP1
TP3
TP5
TP6
CR3 5.1V
R10 100K
C14 .0027 uf

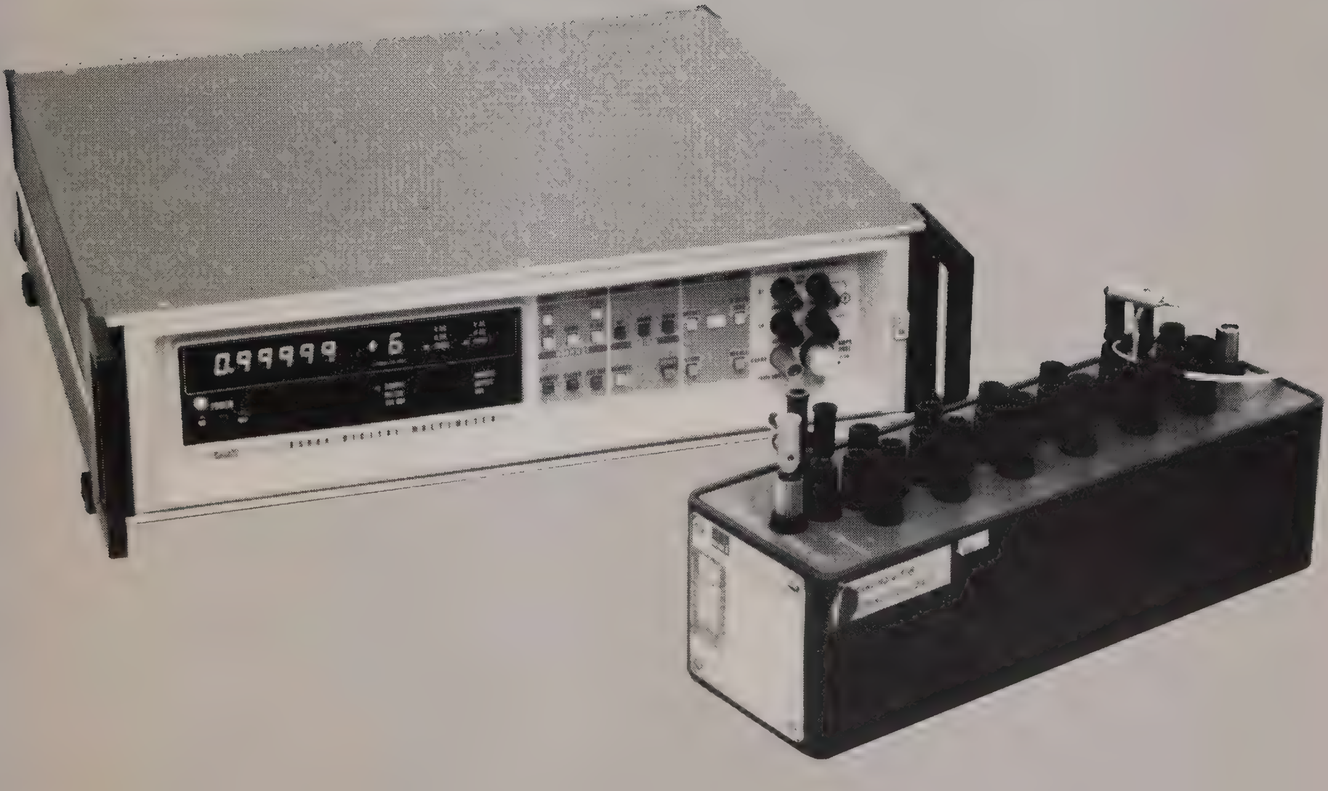
Figure 3. (cont)

FLUKE®

Technical Data

Application Bulletin B0052

8502A/8500A OHM's Guard



INTRODUCTION

Guarding techniques are often used to reduce unwanted currents flowing into or out of sensitive circuits. Leakage can cause unwanted currents in measurement. Like thermal problems, leakage problems have no special identifying features. They show up as unusually large loading errors and can seriously degrade high resistance measurement. As an example of how leakage current paths occur, consider the surface of printed circuit board material. Theoretically, the printed circuit board has resistance higher than 10^{15} ohms. With high humidity and temperature, dirt particles dissolved in water vapor can ionize. These ions will conduct a small amount of current and board resistance drops. A 100,000 MΩ leakage path around a 10 MΩ resistor will cause 0.01% error in the measurement. Leakage across surfaces of electromechanical components such as switches, relays, etc. can effect measurements whenever contamination occurs under high temperature and humidity conditions.

Use of an isolated material such as teflon reduces leakage but this is not always practical. The ohms guarding technique in the 8502A/8500A architecture can be utilized to reduce the effect of leakage significantly.

CIRCUIT DETAILS

The 8502A/8500A ohms converter employs a current drive technique where as a known amount of current (Iref) flows through the reference and unknown resistance. By measuring the voltage across each resistor, the value of the unknown resistance can be determined.

An inverting configuration is used for the ohm's amplifier. The resistor lead connected the HI terminal of the 8502A/8500A stays at reference common potential. Ultra-low bias current of the FET input stage ensures that I_{ref} flows through the resistance under measurement. $R_{unknown}$ is then given by:

$$R_{unknown} = \frac{V_o}{I_{ref}} = \frac{V_o * R_{ref}}{V_{ref}}$$

The summing point of the ohm's amplifier, Node A, is leadage sensitive. Any leakage current entering Node A will then flow through the unknown resistance and degrade accuracy. The measurement accuracy is a function of the I_{ref} and leakage current. The value of I_{ref} for the different ranges is given in Table 1.

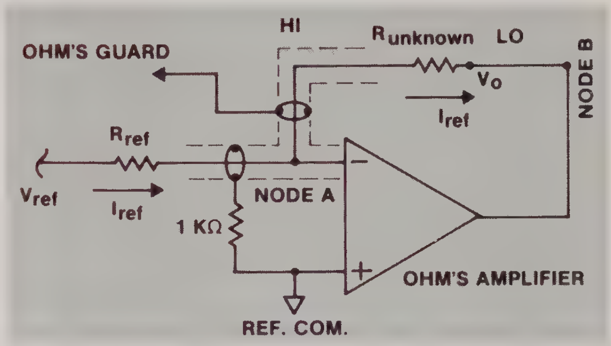


Figure 1.

Example: Assume a leakage current of 100 pA. This current is negligible as compared with I_{ref} for low resistance ranges. However, the 100 MΩ range, I_{ref} is equal to 76 nA. Therefore, leakage current can cause a 13% error in the measurement.

The error due to leakage is eliminated by using a guarding technique in which the OHM's guard surrounds the highly sensitive summing point of ohm's amplifier. The ohm's guard is connected to reference common through a 1 KΩ resistor.

Note: The function of the 1 KΩ resistor is to reduce settling time when large step voltages are applied to the 8502A/8500A input terminals.

HOW TO USE OHM'S GUARD

As shown in Figure 2, OHM's guard is different from instrument guard. Instrument guard is available at the front panel. It is normally tied to INPUT LO. Both ohm's guard and instrument guard are available at the rear input connector (option —17). The following are pin numbers assigned to the rear terminal.

Table 1.

RANGE	FULL SCALE	I_{ref}	FULL SCALE VOLTAGE AT NODE B	CURRENT AVAILABLE TO DERIVE Z_2
10Ω	31.25Ω	10 mA	312.5 mV	2 mA
100Ω	250Ω	10 mA	2.5V	1 mA
1 KΩ	2 KΩ	1.25 mA	2.5V	9.75 mA
10 KΩ	32 KΩ	78 μA	2.5V11 mA	
100 KΩ	256 KΩ	98 μA	2.5V	11 mA
1 MΩ	4.09 MΩ	49 μA	20V	4 mA
10 MΩ	32.768 MΩ	0.61 μA	20V	4 mA
100 MΩ	262.144 MΩ	76 nA	20V	4 mA

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REAR INPUT OPTION —7

	PIN
INPUT HI	S
SOURCE HI	X
INPUT LO	E
SOURCE LO	B
OHM'S GUARD	R
INSTRUMENT GUARD	A

Four terminal measurments should be used for low values of resistances (below 100 KΩ).

The resistor under measurement is connected to the 8502/8500A as shown in Figure 2.

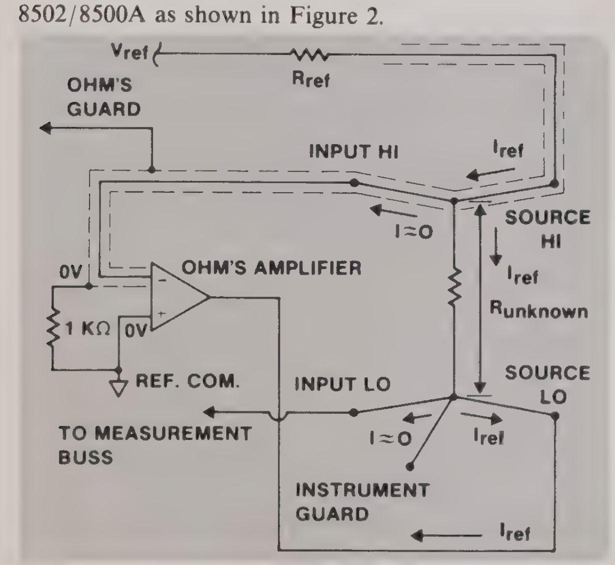
Vref
Rref
OHM'S GUARD
INPUT HI
Iref
I≈0
SOURCE HI
Iref
0V
OHM'S AMPLIFIER
Runknown
1 KΩ
0V
REF. COM.
INPUT LO
SOURCE LO
TO MEASUREMENT BUSS
I≈0
Iref
INSTRUMENT GUARD
Iref

Figure 2.

In order to eliminate error due to common mode voltages, instrument guard should be connected to the LO end of the resistor. Interference from electrostatic and magnetic pickup can further be reduced by using ohm's guard as shown in Figure 3.

In some applications, locating the resistance under measurement close to instrument may not be possible. Also high resistance measurement will be effected by noise pickup. By making use of low-leakage cables (teflon) and with proper shielding as shown in Figure 3, accurate measurements can be made.

CAUTION: Instrument guard and ohm's guard should NOT be tied together. Instrument guard assumes the voltage V which can be as high as -20V on some ranges. Ohm's guard is connected to reference common, and therefore, stays at ground potential.

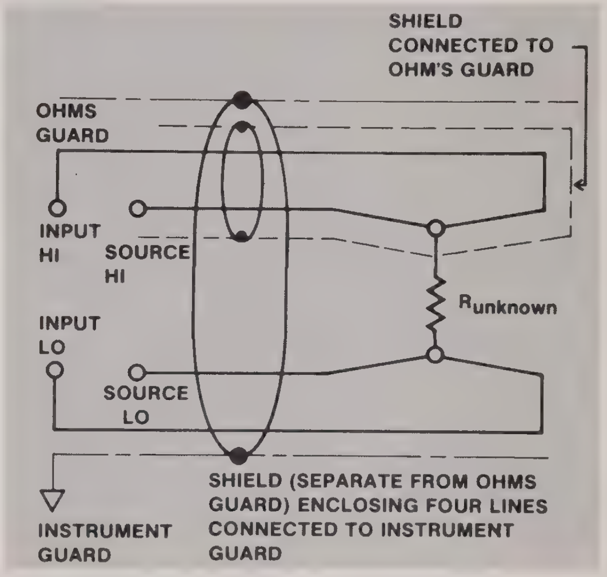
SHIELD CONNECTED TO OHM'S GUARD
OHMS GUARD
INPUT HI
SOURCE HI
Runknown
INPUT LO
SOURCE LO
INSTRUMENT GUARD
SHIELD (SEPARATE FROM OHMS GUARD) ENCLOSING FOUR LINES CONNECTED TO INSTRUMENT GUARD

Figure 3.

MEASUREMENT OF AN IN-CIRCUIT RESISTOR

Individual resistors within passive networks can be measured using ohm's guard. Accuracy of this measurement will depend on the actual topology of the network.

EXAMPLE: Suppose the resistance-under-measurement is a branch of the delta network shown below:

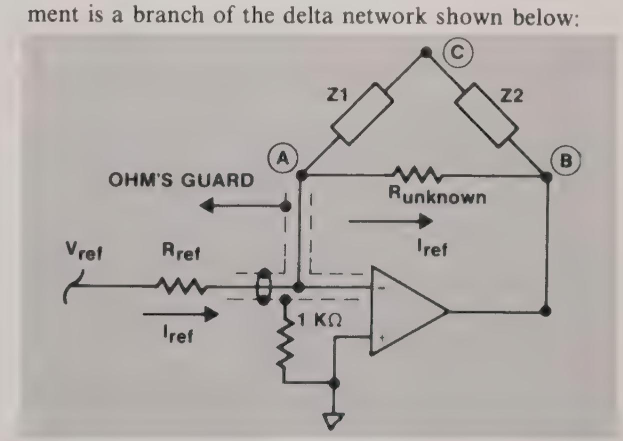
C
Z1
Z2
A
B
OHM'S GUARD
Runknown
Iref
Vref
Rref
Iref
1 KΩ

Figure 4.

An accurate measurement would be possible if I_{ref} flows through $R_{unknown}$ only. However, some current does flow through Z1. Node A is connected to a virtual ground. The ohm's guard is also at ground potential. By connecting Node C to ohms guard, it can be used to ground Node C. Theoretically, with both Node A and Node C grounded, no current will flow through Runknown can then be accurately measured. The practical limitations are discussed as follows.

Assuming that all the current flows through R unknown the full scale voltage on Node B is given in Table 1 for different ranges. Since Node C is at guard potential, the ohm's amplifier must sink the current flowing through Z_2. The current sinking capability of the ohm's amplifier is also listed in Table 1.

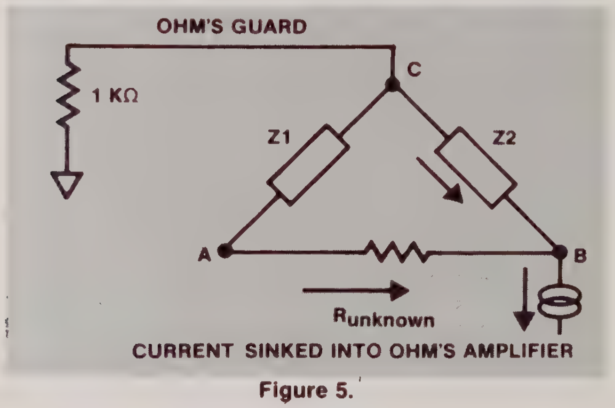
OHM'S GUARD
1 KΩ
C
Z1
Z2
A
B
Runknown
CURRENT SINKED INTO OHM'S AMPLIFIER

Figure 5.

Limitations:

1. The minimum value of Z_2 is given by the voltage at Node B divided by the maximum current available to flow through Z_2.
2. This current also flows through the 1 KΩ resistor between ohm's guard and reference common. Therefore, Node C will assume a negative potential with respect to Node A. Depending on the value of Z_1, part of I_{ref} will flow through Z_1. This will cause an error in the measurement.

This second limitation can be overcome by using a buffer to drive Node C, as shown in Figure 6.

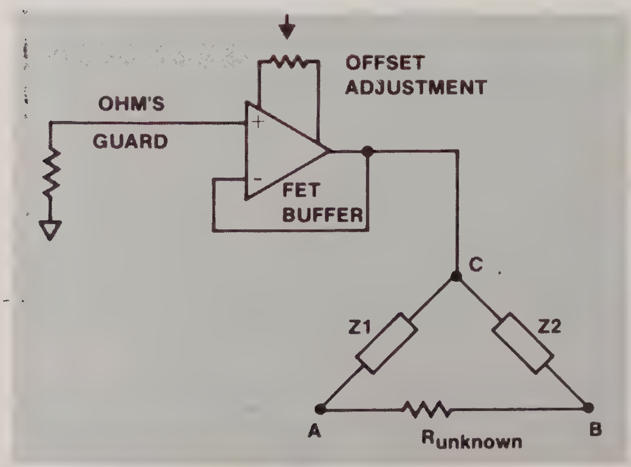
OFFSET
ADJUSTMENT
OHM'S
GUARD
+
-
FET
BUFFER
C
Z1
Z2
A
Runknown
B

Figure 6.

Using the guard technique, an in-circuit resistor can be measured as shown in Figure 7.

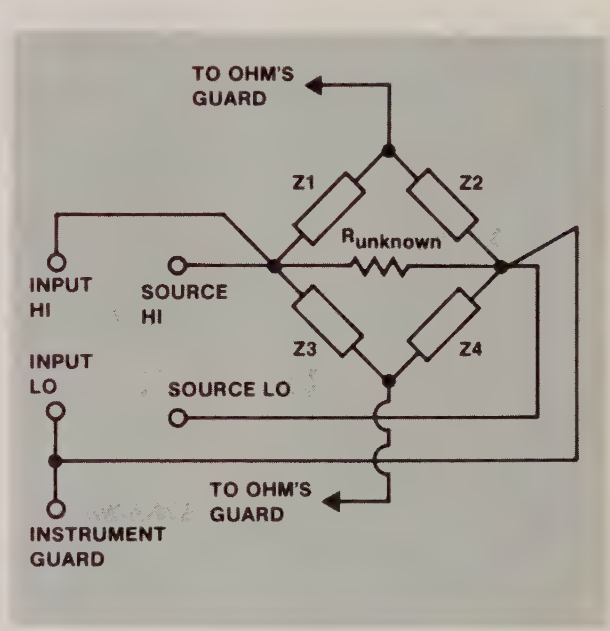
TO OHM'S
GUARD
Z1
Z2
Runknown
INPUT
HI
SOURCE
HI
Z3
Z4
INPUT
LO
SOURCE LO
TO OHM'S
GUARD
INSTRUMENT
GUARD

Figure 7.

The buffer amplifier should be used for better accuracy.

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ERRATA #1: Affects both the operator and calibration manuals.

On page 1-8, Table 1-3, change the specifications as follows:

FROM:

Harmonic 6070A >+13 dBm ≤+13 dBm	-35 -35	-35 -35	-35 -35	-30 -35	N/A
Harmonic 6071A >+13 dBm ≤+13 dBm	-35 -35	-35 -35	-30 -35	-25 -35	N/A -25

TO:

Harmonic 6070A >+13 dBm ≤+13 dBm	-30 -35	-30 -35	-30 -35	-25 -35	N/A
Harmonic 6071A >+13 dBm ≤+13 dBm	-30 -35	-30 -35	-25 -35	-20 -35	N/A -25

***ERRATA #2: Affects only the calibration manual**

On page 5-4, make the following changes to Table 5-2:

CONTROL	CONTROL GROUP	CODE
EXT FM/ØM	MODULATION	03
DC COUPLED	MODULATION	05
LOCAL (BUS ADDRS)	BUS STATUS	07
FREQ	FUNCTION	10
AMPL	FUNCTION	11
MOD FREQ (FREQ STEP)	FUNCTION	12
AM (SWP WDTH)	FUNCTION	13
FM/ØM(SWP-INCR)	FUNCTION	14 *
↓NEXT	MEMORY LOCATION	26
↑NEXT	MEMORY LOCATION	27
↑FREQ	↑ FREQ STEP	52
↓FREQ	↓ FREQ STEP	53
DIGIT ←	EDIT-DIGIT	71 *
DIGIT →	EDIT-DIGIT	72 *

*These items are additions to Table 5-2.

CHANGE/ERRATA INFORMATION

ISSUE NO: 2 10/81

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCB is equal to or higher than that given with each change.
2. No revision letter is indicated at the beginning of the change/errata.

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Print Date:	November 1980
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AB-25

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8502A DIGITAL MULTIMETER
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REMOTE PROGRAMMING THE FLUKE MODEL 8500A/8502A

PART 1

INTRODUCTION

This applications bulletin outlines the remote operation of the 8500A series. Most digital voltmeters operate essentially the same regardless of whether they are operated locally or remotely. Remote interfaces generally convert the remote data to a format that the instrument's logic can interpret. The 8500A/8502A however, is different. Since the 8500A series uses a microprocessor, it handles remote operations in a considerably different manner.

The use of a microprocessor allows a great variety of features to be available to the user. The number of features is so great in fact, that only certain ones have been chosen for local front panel operation. An example of this is the trigger selection. In the local mode, only line synchronous reading rates have been provided; while in the remote mode, there are asynchronous reading rates. We have optimized the different features for best bench operation from the front panel.

When operated remotely, the user will find a greatly expanded measurement capability. This measurement power is available when any of the three remote interface options are selected. In addition to the expanded features, high speed modes may be used when operating remotely. Sampling speeds as fast as 500 samples/second may be selected when using the duplex parallel interface. During this operation, only raw binary data is output due to the speed requirements.

Programming cards for the 8500A and 8502A are available, which outline all of commands described here in part 1.

Three interface options are offered for use with the 8500A Series. These are:

Option 8500A-05, IEEE-488 Standard Interface
Option 8500A-06, Bit Serial Interface
Option 8500A-07, Duplex Register Parallel Interface

These interfaces are mutually exclusive, that is, only one may be installed in a given instrument. All interfaces are field installable merely by removing the Model 8500A/8520A top cover and inserting the interface into the rear slot. When equipped with any remote interface, the 8500A must also have an Interface Isolator, Option -08 (-08A with the 8502A), installed to provide for isolation between internal and external common ties. Once installed, the isolator can be used with any interface module.

PROGRAMMING

Program Sequence

When programming the 8500A series remotely, there is a sequence of commands that will determine the range, function, speed, etc., of the instrument. When power is applied or a reset character is transmitted, the instrument assumes a starting or "reset" condition. The "reset" condition is defined as follows:

RESET CONDITIONS

REMOTE CODE	CONDITION
V	Volts DC
R4	1000V Range
S7 (8502A) S5 (8500A)	2^5 or 2^7 Samples Per Reading
F0	Fast Filter, Timeout Disabled (Panel Indicator Off)
X0	External Reference/Scaling Disabled
P0	Offset Feature Disabled
U0	Limits-Peak Value Storage Disabled
T0	Single Reading Line Synchronous
B0	Single Character ASCII Format
D0	Front Panel Display Active
L0	Deactivate Local Lock Out
Y0	Echo Capability Disabled (Half-Duplex)
J0	Deactivate Line Feed Suppression
M0	Enable Cal Memory Factors
Q0	Disable External Trigger (8502A)
W	No Delay (8502A)

FUNCTION	STATE ASSUMED
Remote/Local	Local
Offset	Zeroed
V dc Zero	Zeroed (Retained if Cal Memory Option -04 Installed)
Ohms Zero	Zeroed (Retained if Cal Memory Option -04 Installed)
Cal Memory Factors	Retained (Applicable Only When Cal Memory Option -04 Installed)
8/16 Bit Mode	8 Bit (Applicable Only when Duplex Reg I/F Option -07 Installed)
Peak Values	Cleared
Limits Values	Zeroed
Ext. Ref/Scaling Values	1

General

The model 8500A/8502A, when equipped with any of the remote interface options, is programmed through a "command string" format. All characters transmitted to the 8500A/8502A via any of the remote interfaces (Bit Serial Asynchronous, IEEE-488 and Duplex Parallel) must be ASCII 7-bit upper case characters. A command string is a sequence of 1 to 31 characters, consisting of one or more of the following character types: IMMEDIATE, COMMAND, and TERMINATION.

The 8500A may be placed in Remote Mode with BIT SERIAL (-06) or DUPLEX PARALLEL (-07), option, by toggling the front panel REMOTE pushbutton or by transmitting any character that the 8500A will recognize from the remote controlling terminal. With the IEEE option (-05), the 8500A/8502A will go into remote only when it receives a MLA (See Part 2). When in Remote Mode, the only front panel switch that is active is the REMOTE switch, providing that it is not locked out by the local lockout command.

IMMEDIATE CHARACTERS

There are five immediate characters so named since they cause an immediate action. An immediate character may be executed at any time and does not require a termination character.

* Reset

The immediate character "*" sets the 8500A Series to a "reset" condition as described in an earlier paragraph. When this command is issued, it must not be followed by any character for approximately 3 seconds; e.g., any carriage return and/or linefeed following the "*" must be suppressed. This is required because the microprocessor resets the remote interface as well as the instrument. During this period, the remote interface is unable to accept programming characters.

% Halt

The "%" character is used to halt a reading which is in progress; in particular if the instrument has been placed into the continuous reading mode, that mode will be terminated and the 8500A Series will wait for a command string. When the "%" character is received, the transmission of readings is terminated immediately even if a reading has not been completely transmitted. The following trigger mode transitions will occur:

> If in continuous line synchronous — single reading line synchronous
>
> If in continuyous asynchronous — single reading asynchronous

Go To Local — Lockout Remote

The "#" character will command the instrument to enter local mode of operation and lockout the remote interface. The remote mode can be reentered only after the front panel REMOTE button has been pushed. This command is for BIT SERIAL (-06) or DUPLEX PARALLEL (-07) interface only.

NOTE: *The state of the 8500A when changing from remote to local operation will be modified as follows:*

> *Ohms fast mode will be ignored*
>
> *Scaling mode will not be in effect*
>
> *If the high averaged sample rate was in effect, the sample rate will be set to* 2^7 *(i.e., 128 samples/reading)*

The state of the 8500A/8502A when changing from local to remote operation will be modified as follows:

> *Ohms fast mode, scaling mode, and continuous mode will be resumed if the instrument was in that mode when it was placed into local.*
>
> *High averaged sample rate will be reinstated if the instrument was in that mode when it was placed into local.*
>
> *The last local error that occurred (if any), will be remembered and be available for recall by "getting" status.*

! Hi-Speed Reading Mode

The "!" character is uded to enter the HI-SPEED reading mode. For the 8500A this mode is only available with the duplex parallel (-07) interface. For the 8502A this mode is available with the IEEE (-05) and duplex parallel (-07) interfaces. The "!" character triggers the first reading in the same way as a "?" (see later). Each successive "?" or TTL Trigger (8502A only) will trigger and transmit data in a three byte two's complement binary format. The three byte binary word is a voltage or current reading only. Appendix A contains a further discussion of the HI-SPEED Reading Mode.

/ 8/16 Bit Toggle

The "/" character is uded only with the Duplex Parallel Interface, Option -07. It is used to toggle from the 8-bit to the 16-bit mode, and vice versa. When the "/" character is used to toggle from one mode to another, the immediate and or termination character must be placed in the least significant byte (LSB) of the programming word. Refer to Appendix B for details.

TERMINATION CHARACTERS

Termination characters cause the execution of a command string. They are normally placed at the end of each programming statement.

$ Clear The Command String

The "$" character is used to erase an incorrect programming entry from the command string buffer. It deletes all characters issued back to, but not including, the predeeding termination character. A new command string is then needed to modify the state of the 8500A/8502A. This character is normally used only when operating with the bit serial interface, such as with a terminal.

, Execute The Command String

The "," character is used to cause the execution of the previous command string. It does not trigger a reading or produce an output from the 8500A Series; it puts the instrument in the defined state only.

When programming a string of characters, it is good practice to use the execute character "," at frequent intervals so that if an error is made, the string need only be cleared back to the last ",". They also are required if the command string is larger than 31 characters.

? Execute The Command String And Trigger

The "?" character will cause the execution of a previously entered command string (if any), take a reading and transmit that reading through the remote interface. If a command string was not entered immediately preceeding the "?" character, the 8500A/8502A will be in the last defined state and in that state take and transmit a reading.

Thus, a single "?" character will cause the 8500A series to trigger and transmit a reading just as if the "?" character is an immediate character.

One exception occurs when a command string containing a "get" specification has been entered; in that case, the 8500A/8502A will respond with the value or status that was requested by the command string and not take a new reading.

When issuing a program string terminated by a "?" character, the CR and/or LF delimiter characters normally output by a computer/controller should be suppressed.

If an error occurs during the reading, a single "0" followed by a (CR) will be transmitted. At that point status should be requested to determine the cause of the error.

@ Execute, Trigger, And Interrupt When Ready

The "@" character is used to cause the triggering of a reading and the generation of an interrupt when the reading is done.

The function of the "@" termination character is in all other respects similar to the "?" termination character.

The methods of providing an interrupt depends upon the interface being used; the bit serial and the duplex parallel interrupt by the transmission of a single (CR—; the IEEE-488 interface asserts a service request on the IEEE-488 bus.

With the IEEE-interface the "GET" Group Execute Trigger Bus command causes the instrument to respond as if it were programmed with the "@" character.

In order to obtain the reading that was generated by "@" termination character, a "get" command should be inserted in the following command string, terminated by a "?" character.

COMMAND CHARACTERS

The command characters can be divided into five groups:

Function
DC and AC Volts, DC and AC Amps, Ohms

Range
Discrete Range or Autorange

Modifiers
Sample Rate (samples/reading), Filter (slow, fast, bypass, time-out), Trigger (continuous, single, synchronous, asynchronous), Offset (offset on-off), External Reference (on-off scaling), Limits (on-off, peak value storage).

Control
Binary or ASCII Output, Display, On-Off, Local Lockout, Echo, Trigger Internal or External, Delay.

Memory
Value Stored For: VDC, Ohms, Offset, Ext Ref. Numeric Entry Upper and Lower Limits/Scaling Values Recalled For: Previous Reading, DC Zero, Status, Offset, Ext Ref, Upper Limit, Lower Limit, Lowest Value Found, Highest Value Found/Scaling.

FUNCTION COMMAND CHARACTERS

There are 7 function command characters: The following characters select the multimeter functions.

V — DC Volts
VA — AC Volts
C — DC Coupled AC Volts (-09 only)
I — DC Current
IA — AC Current
Z — Ohms
Z1 — Fast Ohms

When the function is changed, the state of the instrument is changed as follows:

Range
Auto

Modifiers
Unchanged except that the "Offset" is "off", limits is "off" and numeric values are lost for 8500A and not lost for 8502A.

Control
Unchanged

Memory
Unchanged

If an optional function is selected, the function of the instrument will be undefined and the error code will be set to 19.

Z1 Function Command Character

The "Z1" character string will place the 8500A/8502A into the ohms function and fast ohms mode. In normal ohms operation, the unknown resistor value Rx is determined by three measurements:

V^1-V^2 which is the voltage across an internal precision reference Rr and Vo which is the voltage across the unknown resistor Rx.

The value Rx is then computed by the application of Ohm's Law.

$Rx = Vo\ (Rr/(V^1-V^2))$

In the fast ohms mode, $Rr/(V^1-V^2)$ is stored and assumed to be constant until a function change, range change, or overrange condition occurs. The 8500A measures V^0 and multiplies by the constant $Rr/(V^1-V^2)$ to obtain the result Rx.

In the regular ohms mode, all voltages (V°,V^1 and V^2) are measured to calculate Rx.

RANGE COMMAND CHARACTERS

There are eight range commands which will specify the following by function:

	V	**VA or C**	**I**	**IA**	**Z, Z1**
	DC VOLTS	**AC VOLTS**			**OHMS**
R	Auto	Auto	Auto	Auto	Auto
R0	312.5 mV	Auto	312.5 μA	312.5 μA	21.25Ω
R1	2.5V	2.5V	2.5 mA	2.5 mA	250Ω
R2	20V	20V	20 mA	20 mA	2 kΩ
R3	160V	160V	160 mA	160 mA	32 kΩ
R4	1280V	1280V	1.280A	1.280A	256 kΩ
R5	Auto	Auto	Auto	Auto	4.096 MΩ
R6	Auto	Auto	Auto	Auto	32.768 MΩ
R7	Auto	Auto	Auto	Auto	262.144 MΩ

NOTE: Values shown are full scale values for each function and range.

MODIFIED COMMAND CHARACTERS

There are 7 modifier command characters:

S – Sample Rate
F – Filter
T – Trigger
P – Offset
X – External Reference – Scaling
U – Limits-Peak Value Storage
H – Hi-Averaged Sample Rate

S or H Samples/Reading

The modifier command character "S" is followed by a digit (0 through 7) specifying the number of samples per readings as follows:

S0 – $2^0 = 1$ Sample/Reading (4 MS)
S1 – $2^1 = 2$ Samples/Reading (8 MS)
S2 – $2^2 = 4$ Samples/Reading (17 MS)
S3 – $2^3 = 8$ Samples/Reading (33 MS)
S4 – $2^4 = 16$ Samples/Reading (67 MS)
S5 – $2^5 = 32$ Samples/Reading (134 MS)
S6 – $2^6 = 64$ Samples/Reading (267 MS)
S7 – $2^7 = 128$ Samples/Reading (534 MS)

The modifier command character "H" is followed by a digit (0 through 9). The "H" modifier command character is an extension of the "S" modifier command character. The next higher rate above S7 is H0.

H0 – $2^8 = 256$ Samples/Reading (1.1S)
H1 – $2^9 = 512$ Samples/Reading (2.1S)
H2 – $2^{10} = 1{,}024$ Samples/Reading (4.3S)
H3 – $2^{11} = 2{,}048$ Samples/Reading (8.5S)
H4 – $2^{12} = 4{,}096$ Samples/Reading (17.1S)
H5 – $2^{13} = 8{,}192$ Samples/Reading (34.1S)
H6 – $2^{14} = 16{,}384$ Samples/Reading (68.3S)
H7 – $2^{15} = 32{,}768$ Samples/Reading (2 Min 17S)
H8 – $2^{16} = 65{,}536$ Samples/Reading (4 Min 33S)
H9 – $2^{17} = 131{,}072$ Samples/Reading (9 Min 6S)

NOTE: The times shown above are approximate digitizing times per reading for 60 Hz line synchronous operation with either dc volts, current, or ac volts functions programmed.

F Filter

The "F" character is used to specify the amount of filtering and whether a time-out for the filter settling is to be enabled. The time-out causes a delay between a trigger command received and the actual reading to be taken. In the continuous trigger modes, the time-out will occur before each reading is initiated. Since there are two filter bandwidth settings, there are two time-outs; one associated with slow filter (approximately 500 ms) and one associated with fast filter (approximately 50 ms).

The 8500A series recognizes the following "F" modifier command characters:

F – Slow, Filter, Time-Out Disabled
F0 – Fast Filter, Time-Out Disabled
F1 – Bypass Filter, Time-Out Disabled
F2 – Slow Filter, Time-Out (approximately 500 ms) Enabled
F3 – Fast Filter, Time-Out (approximately 50 ms) Enabled

T Trigger

The "T" character specifies the trigger mode of the instrument, it will select whether samples to be averaged for a reading are taken line synchronous (every 4 or 5 ms) or line asynchronous (approximately every 1.7 ms), and whether a single reading is to be taken or continuous readings.

T – Continuous Reading Mode/Line Synchronized
T0 – Single Reading Mode/Line Synchronized
T1 – Continuous Reading Mode/Line Asynchronous
T2 – Single Reading Mode/Line Asynchronous

Single reading mode requires one "?", "@", "GET" or TTL trigger per reading. Continuous reading mode requires only one "?", "@", "GET" or TTL trigger to start continuous readings. Each reading must be accepted by the controler (IEEE or Duplex Parallel interface) before the next reading can be completed. The "%" character is used to exit the continuous reading mode.

NOTE: When the asynchronous modes are selected, the display will be turned off in order to save time; the front panel switches with the display off are ignored.

P Offset

The "P" character specifies whether a reading is to have an offset value subtracted from it.

P – Offset Subtracted (ON)
P0 – Offset Not Subtracted (OFF)

The offset value may be stored either by entry from front panel, "Keeping" the previous reading as an offset or "Keeping" a numerically entered offset.

X External Reference – Scaling

The "X" character sets the external reference/scaling mode. This mode is valid for any function and any range. In this mode, all readings are divided either by the signed magnitude of the external reference voltage in volts or by a numerically entered scale factor or previously taken external reference voltage.

X – External Reference "On", Scaling "Off"
X0 – External Reference "Off", Scaling Mode "Off"
X1 – Scaling Mode "On", External Reference "Off"

The "X" external reference mode uses the external reference voltage Vxref as a dividing scale factor. Every reading cycle this voltage is measured and all readings are divided by this measured voltage.

Minimum Vxref = ± 0.0001V, or or V Input/max. display within range Volts (8500A Only) or Input/10^9 (8502A only)

Maximum Vxref = ±40V between EXT Ref Hi and Low Terminals, providing neither terminal is greater than ±20V relative to the Sense Lo or Ohms Guard Terminals.

Reading = INPUT/Vxref

The "X1" scaling mode will divide all readings by a previously taken external reference voltage or by a previously entered numeric scale factor SF which has a range given by

Minimum SF = Same as Vxref minimum (10^{-9} for 8502A)
Maximum SF = ±100 (8500A) or a number such that INPUT/Max SF is less than 10^{-9} (8502A)
Reading = INPUT/SF

The "X" and "X1" modes are mutually exclusive; i.e., only one may be activated at any one time.

Note that in conjunction with the offset feature any linear transformation of the form

$$y = mx + b$$

can be programmed where "x" is the unscaled reading, "-b" is the stored offset, "m" is the stored value "1/SF" and "y" is the final displayed reading. The value "y" may be interpreted in any units appropriate to the user since the scaling factor may be constructed so as to give any desired units within the display limits of the 8500A.

Refer to Appendix C for a typical use of scaling.

U Limits - Peak Value Storage

The "U" character specifies whether a test for limits (or Peak Value Storage) is to be performed. In the limits "on" mode, each reading is compared to upper and lower limits which have been entered with a keep command (see section Memory "Keep" Characters.)

U – Limits Testing On (Values Must be Preset)
U0 – Disable Limits/Peak Value Storage
U1 – Save Highest and Lowest Values (Peak Values)

Previous higher and lower values are erased from memory whenever "U1" is programmed or is changed.

Limits may be stored by "Keeping" a numeric value as an upper or lower limit.

For 8500A limits and peak value storage are mutually exclusive, while for the 8502a they can both be used at the same time.

NOTE: Limit tests are applied after all other modifier modes such as scaling, offset, etc. have been applied.

LIMITS OUTPUT FORMAT

"0"	for reading between limits
"1"	for above upper limit
"-1"	for below lower limit
"2"	if an error occurs (such as overranging)

The total output format then is 3 or 4 ASCII characters.

SIGN	**0/1/2**	**CR**	**LF**

CONTROL COMMAND CHARACTERS

There are 6 control command characters:

B – Binary or ASCII Output Format
D – Display ON/OFF
L – Local Lockout
Y – Echo Characters
J – Inhibit (LF)
M – No cal adjustment

B Input/Output Format

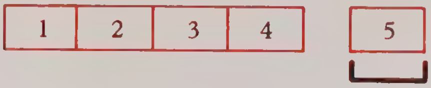
The "B" character selects the binary or ASCII format.

B – Binary Format
B0 – ASCII Format
B1 – Binary 16 Bit Parallel (Duplex Register Only)
B2 – ASCII 16 Bit Parallel (Duplex Register Only)

The front panel display is turned on when the ASCII mode is entered, off when Binary mode is entered.

THE BINARY OUTPUT FORMAT:

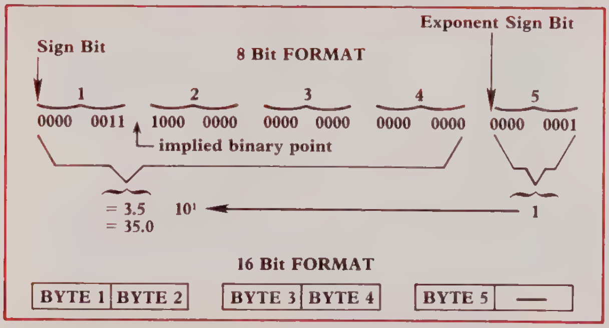
The binary output format consists of five characters:



Decimal exponent (two's) comlement

The implied binary point is between first and second character. The first four bytes contain a 32-bit binary two's complement fixed point number. The fixed binary point is located between the first and second bytes giving 8 bits as the integer portion and 24 bits of binary fraction. Because this format cannot be used to hold the entire range of possible values for the DMM, a fifth byte is used as an exponent. The exponent is an 8-bit two's complement binary number representing the decimal exponent of the 32-bit binary fixed point number contained in the lower 4 characters.

EXAMPLE:



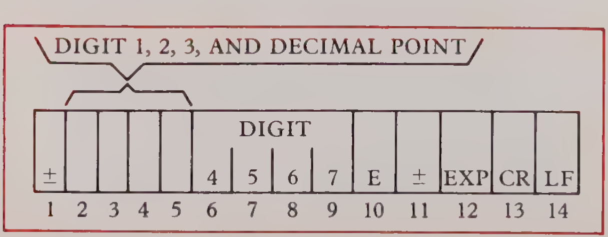
NOTE: In dc volts and ac volts, the exponent is always 1. In dc and ac current, the exponent is always -2. The exponent is range dependent in ohms function; i.e., 1 for Ω ranges, 4 for kΩ ranges, and 7 for MΩ ranges.

When in binary mode with limits testing activated the response is a single byte 8 bit binary two's complement number.

Errors are indicated by 4 bytes of "0" with a "0" exponent byte.

THE ASCII DATA OUTPUT FORMAT

The ASCII data format consist of 14 characters:



The seventh digit in the ASCII format corresponds to the "Cal" or HI RES digit of the front panel display. In some ranges and functions (e.g., 100 mV dc) this digit is permanently zeroed since it exceeds the resolution of the 8500A/8502A. (When not in the "Cal" "HI RES" mode, the front panel will display the value of the reading rounded to 6 significant digits.)

D Display Control and L Local Lockout

The "D" command turns the display on or off. With the display off, the 8500A series is no longer interrogating any of the front panel switches; so turning the display off causes a local lockout condition.

D – Display Off
D0 – Display On
L – Local Lockout On
L0 – Local Lockout Off

Y Echo Control

The "Y" character will cause the 8500A to either commence or terminate echoing of characters. (Applicable only with bit serial interface, Option -06.)

Y – Echo On (Full-Duplex)
Y0 – Echo Off (Half-Duplex)

J Line Feed Control

The "J" character suppresses the (LF) sent out at the end of a response line. "J0" is the default mode. The "J1" characters suppress all output from the 8500A/8502A. In single trigger mode of operation the instrument will not output any reading in this mode. In continuous mode of operation the instrument will take continuous readings and not output any of them. This mode (J1) is useful for Peak Value Storage operation (see "U" commands). It is necessary to use "J" or "J0" to exit this mode when Peak Values or any measurement is to be outputed.

J – < CR >
J0 – < CR > <LF >
J1 – Suppress all output

M Calibration Constant

The "M" character inhibits the adjustment of readings by the calibration memory correction factor. This will slightly increase the speed of readings. It has no effect if calibration memory Option -04 is not installed.

M – Cal Constant not applied
M0 – Cal constant applied

Trigger Command Characters

This set of command characters are available for the 8502A equipped with option -08A.

Q – External Trigger
W – External Trigger Delay

Q External Trigger

The "Q" character selects internal or external trigger format.

Q — Extend trigger to initiate reading and then

interrupt when ready
Q0 – Internal trigger to initiate reading with the external trigger input ignored.
Q1 – External Trigger to initiate the reading and then transmitt.

When in the external trigger mode a "?" input will also initiate a reading.

W External Trigger Delay

The "W" command selects the amount of delay between the trigger signal and initiation of the reading.

W – No delay
W0 – 2.083 mS
W1 – 4.166 mS
W2 – 8.332 mS
W3 – 16.66 mS
W4 – 33.33 mS
W5 – 66.66 mS
W6 – 133.3 mS
W7 – 266.6 mS
W8 – 533.2 mS
W9 – 1.066 mS
W10 – 2.133 mS
W11 – 4.266 S
W12 – 8.532 S
W13 – 17.06 S
W14 – 34.13 S
W15 – 68.26 S

MEMORY COMMAND CHARACTERS

There are two forms of memory control:

Store into Memory: Keep;
The "K" character will specify the storing of a reading or numeric entry.

Recall from Memory: Get:
The "G" character specifies that a reading, numeric entry or status is to be read from the 8500A memory.

The "?" termination character is used to generate any GET response.

K "Keep" Command Characters

The following memory "Keep" commands are recognized by the 8500A:

K – Keep Last Reading as Offset
K0 – Keep Last Voltage Taken as V DC Zero*
K1 – Keep Last Reading as Ohms Zero*
DNP – Keep Numeric Value Following as Offset
KNX – Keep Numeric Value Following as Scaling Factor
KNU – Keep Numeric Value Following as Upper Limit
KNL – Keep Numeric Value Following as Lower Limit

* *May only be performed on lowest range (RO)*

NUMERIC ENTRY FORMAT

Offsets, Scaling Factors, Upper and Lower Limits may be entered via the "KN" command characters followed one of the modifier characters "P", "X", "U" or "L" and the numeric value which is an ASCII string of numeric characters, and optional sign, decimal point and signed decimal exponent digit in "E" notation.

Examples of legal numeric strings are:

"KNP 10"
Keep numeric offset of 10.0

"KNX 10.3E-1"
Keep numeric scaling factor of 10.3 x 10^1 or 1.03

"KNU 7.6E4"
Keep numeric upper limit of 7.6 x 10^4 (only valid in Ohms)

"KNL-123.456
Keep numeric lower limit of -123.4567

Some illegal strings are:

"KNP 1.2E9"
Exceeds numeric limits of all functions

"KNX 2.0E-13"
Exponent is limited to one signed integer digit, in this case the exponent would be -1 and the "3" would be ignored.

G "Get" Command Characters

G – Get Previous Reading and send on next Trigger
G0 – Get DC Zero and send on next Trigger
G1 – Get Status and send on next Trigger (see status format next paragraph)
GNP – Get Offset and send on next Trigger
GNR – Get External Reference factor and send on next Trigger (8502A only)
GNX – Get External Reference/Scaling factor and send on next Trigger (8500A only) or get Scaling factor (8502A only)
GNU – Get Upper Limit and send on next Trigger
GNL – Get Lower Limit and send on next Trigger
GNQ – Get Lowest Value Found and send on next Trigger
GNW – Get Highest Value Found and send on next Trigger

NOTE: The "Get" commands must never be followed by a trigger character "?".

Status Format

Status information from the 8500A/8502A may be obtained in the following format with memory command character "G1".

Characters 1 and 2 of the status information contain error code:

00 – No Error
06 – System Error
07 – Illegal Numeric Entry

08 – Remote Command String Error
09 – Remote Overrange
10 – V DC Zero/Ohms Zero Error
11 – Offset Error
12 – Filter Module Faulty or not installed
13 – DC Amp Module Faulty or not installed
14 – Excessive voltage present at terminals for Ohms/Current Measurement
15 – Fast A/D Converter Faulty or not installed
16 – Numeric Display Overflow
17 – Magnitude of External Reference Input >20V
18 – Controller Module Faulty
19 – Function Module selected not installed

NOTE: The least significant digit of the error code is displayed on the 8500A/8502A front panel; error codes with a first digit of zero are related to remote operation only.

Character 3 of the status information contains the range information.

Character 4 of the status information contains the sample rate (2y) low sample rate only.

Character 5 of the status information contains the function code:

0 – DC Volts
1 – AC Volts
2 – DC Amps
3 – AC Amps
4 – Ohms
5 – DC Coupled AC
7 – Function Not Defined

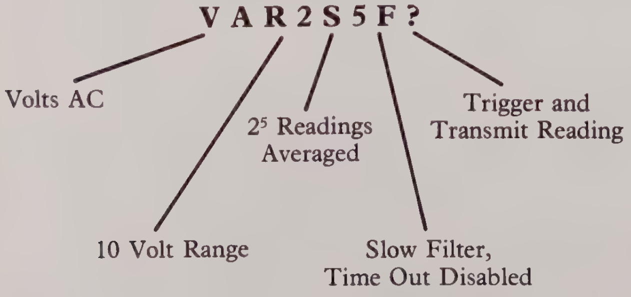
Concluding: Status format is as follows:

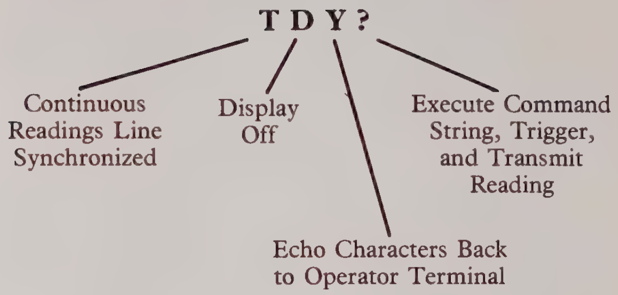
CHARACTERS

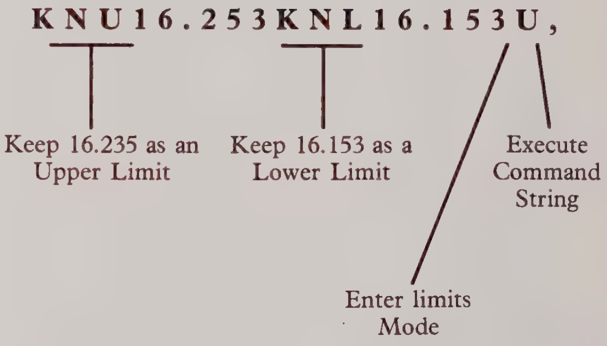
1	2	3	4	5	(CR)	(LF)
Error Codes		Range Codes	Sample Rate	Function	Carriage Return	Line Feed

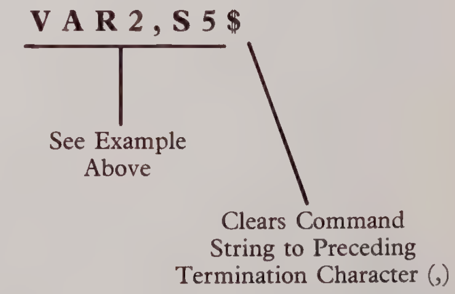
Example Command Strings

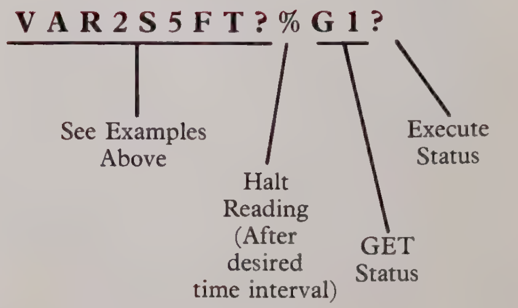
The following is an example of different command strings and an explanation.


V A R 2 S 5 F ?
Volts AC
10 Volt Range
2⁵ Readings Averaged
Slow Filter, Time Out Disabled
Trigger and Transmit Reading


T D Y ?
Continuous Readings Line Synchronized
Display Off
Echo Characters Back to Operator Terminal
Execute Command String, Trigger, and Transmit Reading


K N U 1 6 . 2 5 3 K N L 1 6 . 1 5 3 U ,
Keep 16.235 as an Upper Limit
Keep 16.153 as a Lower Limit
Enter limits Mode
Execute Command String


V A R 2 , S 5 $
See Example Above
Clears Command String to Preceding Termination Character (,)


V A R 2 S 5 F T ? % G 1 ?
See Examples Above
Halt Reading (After desired time interval)
GET Status
Execute Status

INTERFACING THE FLUKE MODEL 8500A SERIES USING THE IEEE-488 INTERFACE

PART 2

INTRODUCTION

This application bulletin outlines the use of the Model 8500A/8502A when equipped with Option 8500A-05 IEEE Standard Interface. The user must also refer to Part 1, "Remote Programming the Model 8500A/8502A," which provides detailed programming information regardless of the type of interface used. Note the Model 8500A/8502A may also be equipped with a Bit Serial Interface, Option 8500A-07. Refer to Part 3 and Part 4, respectively.

INTERFACE DESCRIPTION

Option 8500A-05, IEEE-488 Interface

The IEEE interface provides input/output compatibility per the IEEE-488-1975 Standard Specifications. This is also known (not necessarily correctly) as the ASCII BUS, HPIB, GPIB, or the IEC BUS. Rather than go into a detailed discussion of the standard, the reader is referred to Fluke AB # 36 or the actual publication (IEEE Std 488-1975) "IEEE Standard Digital Interface for Programmable Instrumentation," published by:

> The Institute of Electrical and Electronic Engineers, Inc. 345 East 47th Street; New York, N.Y. 10017

The interface is designed to be remotely controlled by a large variety of program sources such as a computer or system controller. Up to 15 IEEE Standard instruments or devices may be interconnected as a system. Some typical controllers are:

Data General Models, 5280AR and 5702I
DEC Model IBV11-A
Tektronix 4051 Graphic System
H-P 9800 Series Calculators
H-P 2100 Series Computer
Keithley System One with 7802-ISB Card
Compucorp Model 425-IS Calculator
WANG 2200 Series Systems

System Connection

Connection to the system is made with an IEEE Standard 24 pin cable. Cable lengths of 1, 2, and 4 meters are available from Fluke (P/N's Y8001, Y8002, Y8003, respectively). The maximum length of cable that can be used to connect a group or devices is: 2 meters times the number of devices within the bus system, or 20 meters, whichever is less. Cables may be interconnected in any manner deemed suitable by the user (that is, star linear, or combinations thereof). The connector (J3) on the Option - 05 interface is accessible through a hole in the rear panel of the Model 8500A/8502A (Figure 1).

Each cable in the chain is alike the every instrument connects to all 24 lines in parallel (see Figure 2). Sixteen of the lines are signal lines, the remaining are logic common, signal returns, and a shield. The 16 signal lines are separated into 8 data lines, 3 data byte transfer (handshake) lines, and 5 general interface management lines. The data lines normally carry ASCII control characters and data. The transfer is asynchronous, controlled by the handshake lines, thus speed varies according to the speed of the sender and receiver.

As shown in Figure 2, a system consists of devices connected to a bus, which can perform the following status designations.

Controller
A device which assigns who is going to transmit data (talker) and who will receive data (listener) There may be only one controller and it will service all interrupts. A controller may also be a talker or listener type device.

Talker
A device that will output data to the bus upon command. There may be only one talker assigned or addressed at any one time.

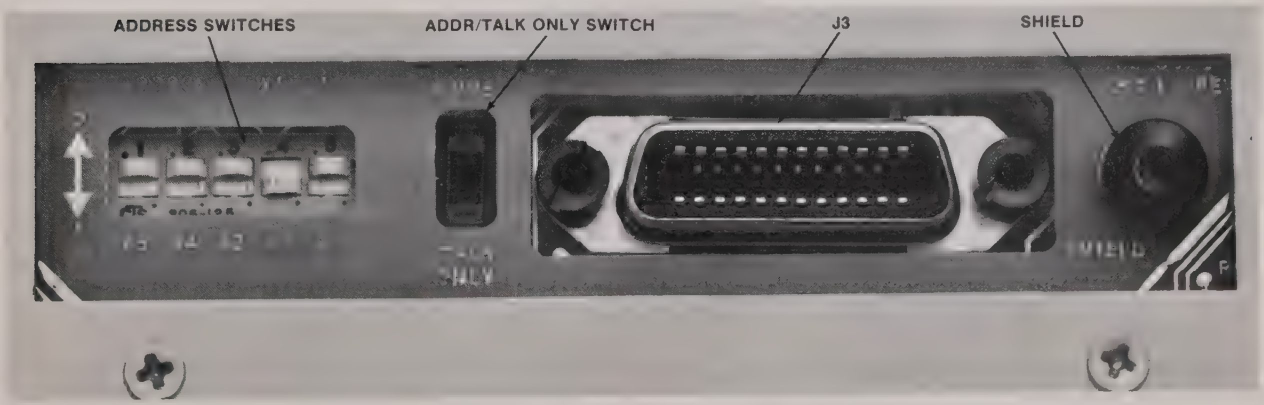


Figure 1. CONNECTOR VIEW IEEE-488 INTERFACE, OPTION -05

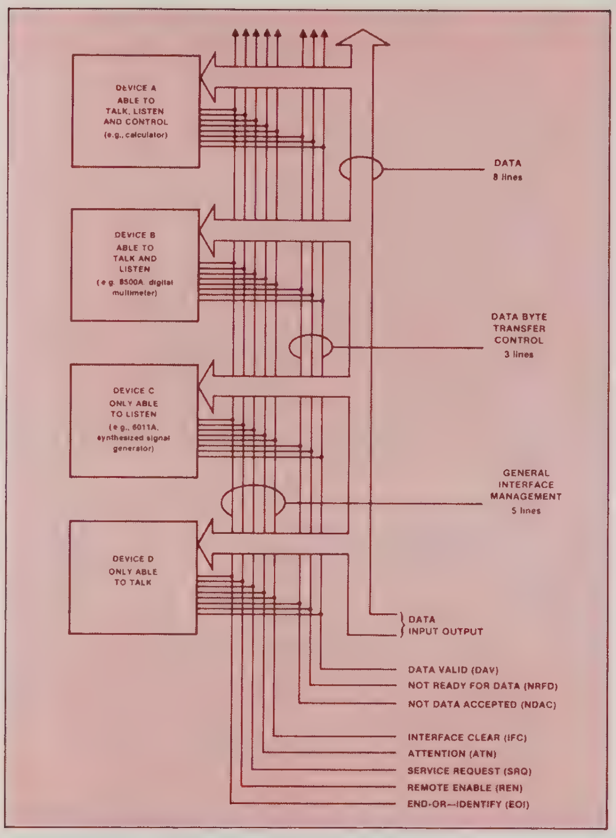

DEVICE A
ABLE TO
TALK, LISTEN
AND CONTROL
(e.g., calculator)
DEVICE B
ABLE TO
TALK AND
LISTEN
(e.g. 8500A digital
multimeter)
DEVICE C
ONLY ABLE
TO LISTEN
(e.g., 6011A,
synthesized signal
generator)
DEVICE D
ONLY ABLE
TO TALK
DATA
8 lines
DATA BYTE
TRANSFER
CONTROL
3 lines
GENERAL
INTERFACE
MANAGEMENT
5 lines
DATA
INPUT OUTPUT
DATA VALID (DAV)
NOT READY FOR DATA (NRFD)
NOT DATA ACCEPTED (NDAC)
INTERFACE CLEAR (IFC)
ATTENTION (ATN)
SERVICE REQUEST (SRQ)
REMOTE ENABLE (REN)
END-OR—IDENTIFY (EOI)

Figure 2. IEEE BUS CONFIGURATION

Listener
A device that accepts bus data upon being properly addressed. There may be up to 14 listeners taking part in any simultaneous bus operation.

Since the Option 8500A-05 is part of a digital multimeter, it has the capability of being addressed as a talker or listener. A device need not be a talker or listener at all times. It may be idle. Any device not address is in an idle state, and therefore has no effect on data communications rates.

Address Switches A1-A5 (Rear Panel)

The position of these switches determines the listen/talk address of the interface. The specific address used is determined by the user. Use a small tool, such as a screwdriver to set the switches. Depressing the switch toggle at the bottom indent sets that particular address bit TRUE. The listen and talk addresses are set in pairs according to Table 1.

ADDR/TALK SWITCH (See Figure 1)

This 2 position switch has 2 functions:

1. When placed in TALK ONLY position the instrument is constantly a talker and will output data whenever a listener on the bus requests it. The 8500A remains in local mode; therefore, function, range, etc. must be setup on the front panel. Operation in this mode does not require a controller. A typical minimum system may consist of an 8500A and a printer, for semi-automatic data logging.
2. Full flexibility and power of the 8500A/8502A using the Option -05 IEEE interface becomes more apparent when connected to a controller. When a controller is used the switch is set to ADDRESSABLE MODE position, enabling address switches A1 through A5. The instrument then becomes fully remote programmable.

Interface Function Repertoire

This interface incorporates the IEEE-488 functions (reference IEEE-Std-488-1975, paragraph 2.1.2.3, page 13) normally found in a programmable measurement instrument. Following is a list of the functions included.

Symbol	**Function**	**Comments**
AH1	Acceptor Handshake	Complete capabilities
L4	Listener	This is basic listener and unaddress if MTA, does not include listen only capabilities.
LE1	Extended Listener	No capabilities
SH1	Source Handshake	Complete capabilities
T5	Talker	Complete capabilities
TE0	Extended Talker	No capabilities
SR1	Service Request	Complete capabilities
RL2	Remote/Local	No local lockout (can be RL1 with local lockout implemented in software)
DC1	Device Clear	Complete capabilities
DT1	Device Trigger	Complete capabilities
CO	System Controller	No capabilities

Table 1. ADDRESS CODING

ASCII Character		Binary	Decimal Equivalent
Listen Address	Talk Address	Address Switches A5 A4 A3 A2 A1	
(SPACE)	@	0 0 0 0 0	0
!	A	0 0 0 0 1	1
"	B	0 0 0 1 0	2
#	C	0 0 0 1 1	3
$	D	0 0 1 0 0	4
%	E	0 0 1 0 1	5
&	F	0 0 1 1 0	6
'	G	0 0 1 1 1	7
(	H	0 1 0 0 0	8
)	I	0 1 0 0 1	9
*	J	0 1 0 1 0	10
+	K	0 1 0 1 1	11
, comma	L	0 1 1 0 0	12
–	M	0 1 1 0 1	13
.	N	0 1 1 1 0	14
/	O	0 1 1 1 1	15

**Depressing address switches A1-A5 at the bottom sets that particular bit TRUE. (1 = TRUE, 0 = FALSE)*

Table 1. ADDRESS CODING CONT.

ASCII Character		Binary	Decimal Equivalent
Listen Address	Talk Address	Address Switches A5 A4 A3 A2 A1	
0	P	1 0 0 0 0	16
1	Q	1 0 0 0 1	17
2	R	1 0 0 1 0	18
3	S	1 0 0 1 1	19
4	T	1 0 1 0 0	20
5	U	1 0 1 0 1	21
6	V	1 0 1 1 0	22
7	W	1 0 1 1 1	23
8	X	1 1 0 0 0	24
9	Y	1 1 0 0 1	25
:	Z	1 1 0 1 0	26
;	[	1 1 0 1 1	27
<	\	1 1 1 0 0	28
=	]	1 1 1 0 1	29
>	↑	1 1 1 1 0	30

**Depressing address switches A1-A5 at the bottom sets that particular bit TRUE. (1 = TRUE, 0 = FALSE)*

Interface Messages

The interface will handshake all messages on the IEEE bus; however, only the ones listed in Table 2 will have an effect on the interface, instrument, or both.

SERVICE REQUEST OPERATION

The service request function allows the interface to get the attention of the controller at any time by asserting the SRQ line. The controller then does a serial poll of the instruments to determine which one is requesting service. The Model 8500A will only issue a service request when it is programmed with the command terminator; -@-” or triggered by the Group Execute trigger (GET) command. The SRQ is issued each time a measurement is completed. The status response of the Model 8500A when serially polled by the IEEE controller is as follows:

	ASCII	OCTAL
SRQ Asserted by 8500A	@	100
SRQ Not Asserted by 8500A	<	074

Whenever the Model 8500A, equipped with option -05 is triggered by the IEEE Group Execute Trigger (GET) command, the instrument will perform as if it was a “@” command.

SAMPLE PROGRAMS FOR TEKTRONIX 4051

The program is written in Tektronix 4051 BASIC language. When operating with other controllers, the appropriate language must be used.

The program is an example of using several features of the Model 8500A series. Namely: scaling, offsets and limits testing. Refer to Appendix C for a detailed description.

Table 2.

MNEMONICS	MESSAGE	MESSAGE CODING										U	A	L	N
		BINARY								Octal	Hex				
MLA	My Listen Address	■	0	1	A5	A4	A3	A2	A1				X	X	1
MTA	My Talk Address	■	1	0	A5	A4	A3	A2	A1				X	X	2
UNL	Unlisten	■	0	1	1	1	1	1	1	077	3F	X			
UNT	Untalk	■	1	0	1	1	1	1	1	137	5F	X		X	
OTA	Other Talk Address	■	■	■	■	■	■	■	■					X	3
SPE	Serial Poll Enable	■	0	0	1	1	0	0	0	030	18	X		X	
SPD	Serial Poll Disable	■	0	0	1	1	0	0	1	031	19	X		X	
LLO	Local Lockout	■	0	0	1	0	0	0	1	021	11	X		X	
GTL	Go To Local	■	0	0	0	0	0	0	1	001	01		X		
DCL	Device Clear	■	0	0	1	0	1	0	0	024	14	X			
SDC	Selected Device Clear	■	0	0	0	0	1	0	0	004	04		X		
GET	Group Execute Trigger	■	0	0	0	1	0	0	0	010	08		X		

0 = FALSE

1= TRUE

■ = *Don't Care*

U = Universal Command

A = Addressed Command

L = Messages that affect the interface or instrument while in local

N1 = Receiving MLA will address the interface as a listener and place the interface and instrument into remote

N2 = The address switches A1 through A5 determine the first five bits of the listen and talk addresses

N3 = OTA is any talk address other than MTA

As shown in the program, the IEEE Interface, Option -05 is addressed to a decimal 2, which corresponds to a listen address of " " " and a talk address of "B". When using the Tektronix 4051, the line feed suppression should be activated by programming code "J". This inhibits the line feed character at the end of an 8500A response. One other point in the program is that when the "*" is used to reset the 8500A, notice that the carrige return and the line feed are suppressed from the Tektronix 4051 by programming a semicolon ";" at the end of the print statement. This is mandatory since the asterisk is an immediate character which causes the 8500A to be reset. During a short interval, the interface is not ready to accept data from the controller.

This problem determines the error in percent of a batch of 47 ohm, 5% resistors.

```
1    INIT
10   REMARK THIS PROGRAM USES
     SCALING, OFFSET AND ULTIMATES
15   REMARK THE 8500A IS ADDRESSED TO
     DECIMAL 2
20   PAGE
100  PRINT @ 2: "*";
105  GOSUB300
110  PRINT @ 2: "ZR1J," (programs 100Ω range and
     line feed suppression)
115  PRINT @ 2: "KNP100," (program offset of 100)
120  PRINT @ 2: "KNX.47," (programs scaling factor of
     0.47)
125  PRINT @ 2: "KNU5," (Programs upper limit of 5%)
130  PRINT @ 2: "KNL-5," (Programs lower limit of 5%)
135  PRINT @ 2: "X1P," (Activates scaling and offsets)
140  PRINT @ 2: "?"; (Triggers measurement)
145  INPUT @ 2: V (Places error in % in variable V)
150  PRINT @ 2: "U," (Activates ultimates testing)
155  PRINT @ 2: "?"; (Performs limits test)
160  INPUT @ 2: L (Places limits response in variable L)
165  PRINT @ 2: "U0," (Disables ultimates testing)
170  LET J= L + 2
175  GOSUB J OF 400, 410, 420, 430
200  PRINT "ERROR IN % ="; V A$
205  GOSUB300
210  GOTO140
300  PRINT "CONNECT RESISTOR TO BE
     TESTED"
305  PRINT
310  PRINT "ENTER 'CR' TO CONTINUE";
315  INPUT B$
320  RETURN
400  LET A$ = "FAIL LO"
405  RETURN
410  LET A$ = "PASS"
415  RETURN
420  LET A$ = "SYSTEM ERROR"
435  RETURN
```

FOR HP 9825A CALCULATOR

This program logs the peak values. The 8500A/8502A is placed in continuous mode and triggered by a Group Execute Trigger (GET) command. This causes the 8500A/8502A to set the SRQ flag upon completion of each measurement. After 500 readings taken the instrument is halted and the peak values are retrieved, then printed. Notice that the 8500A/8502A is programmed with a Write Byte statement. That is done in order to suppress the CR, LF characters. This could have been accomplished by using a format statement which suppresses the CR, LF characters, then writing the formatted statement to the 8500A/8502A. In order for this program to operate, the 8500A/8502A must be addressed to a decimal 2, or statement number 0 must be changed to agree with the 8500A address.

```
 0: dev 'dvm', 70Assigns device 'dvm' to bus address
                 decimal 2
 1: clr 'dvm';   resets 'dvm' and waits 2 seconds
    wait 2000
 2: flt 6        sets floating point format
 3: prt "8502A",
    "Peak
    Voltage"
 4: wtb 'dvm',   programs "dvm" to Vdc, 2 samples/
                 reading
    "VS2U1T,"    Peak Value Storage and continuous
                 readings
 5: trg "dvm"    trigger "dvm" (GET)
 6: for I = 1 to
    500
 7: rds ("dvm")  clears SRQ
      A
 8: if bit (t, rds waits until SRQ assented
    7)) = 0; gto 8
 9: next I
10: wtb "dvm",   stops "dvm" and recalls lowest
    "GNQ?"       value
11: red "dvm",V
    prt "Lowest
    value", V
12: wtb "dvm",   recalls highest value found
    "GNW?"
13: red "dvm"
    V; prt "Highest
    value", V
14: lcl "dvm"    puts "dvm" in local
```

This program is more complicated than the previous 9825A program. The 8502A (only) is used in the Hi Speed reading mode as described in Appendix A. In order for this program to operate, the 8502 must be addressed to a decimal 2 or statement number 3 must be changed.

```
1: "8502A HI-
   SPEED":
2: "8502A ADR
   2":
3: 702    D; fxd 6assigns D to bus address 2
4: clr D         clears 8502A
5: spc 5; prt
   "8502A Hi-
   Speed ","
   reading
   mode"
6: spc 2; prt
   "Connect
   stimulus",
   "between",
     "0 & 2.5
     VDC"
 7:  dsp "Press
     CONTINUE
     ;stp
 8:  spc 1; dsp
     "1000 read-
     ings being
     taken"
 9:  dim F$[3014]
     N[5]
10:  buf "data",  set up data buffer for the 1000
     F$,3         readings
11:  wtb D,       programs 8502A to VDC, Slow Filter,
     "FVR1S       1V range hi Speed reading mode
     0T0!"
12:  tfr D, "data"reads the first reading
     ,3
13:  if rds ("data waits for the buffer to be ready for next
     ")=1; jmp 0  reading
14:  for I=1 to
     999
15:  wtb D, "?";  Triggers and reads next reading
     tfr D,"data" 3
16:  if rds ("datawaits for the buffer
     ")=1; fto 16
17:  next I
18:  lcl D; wtb D,clears 8502A
     "*"
19:  spc 1; prt
     "All 1000"
     "," readings
     are ","
     displayed"
20:  for I=0 to
     999 by 3
21:  for J=1 to 3 converts each reading into 3 bytes of
                  numerical data
22:  num(F$[I+
     J])   N[J]
23:  next J
24:  N[1]*10/2  4 First byte is modified for implied
     V            decimal
25:  N[2]*10/2 12 Second byte is modified for implied
     +V   W       decimal point and added to first byte
26:  N[3]*10/2 20 Third byte is modified for implied
     +V   W       decimal point and added to other bytes.
27:  V/8 V;dsp V;Reader is scaled by range factor and
     wait 200     displayed.
```

INTERFACING THE FLUKE MODEL 8500A/8502A USING THE BIT SERIAL INTERFACE

PART 3

INTRODUCTION

This application bulletin outlines the use of the Model 8500A/8502A when equipped with Option -06, Bit Serial Interface. The user must also refer to Part 1, "Remote Programming the Model 8500A/8502A," which provides detailed programming information regardless of the type of interface used. Note the Model 8500A Series may also be equipped with an IEEE-488 Standard Interface, Option 8500A-05, or Duplex Register Parallel Interface, Option 8500A-07. Refer to Part 2 and Part 4, respectively.

INTERFACE DESCRIPTION

Option 8500-06 Bit Serial Interface

The bit serial asynchronous interface provides either voltage loop (EIA Standard RS-232B or C) or current loop (20 mA) level signals for interfacing to such devices as computers, CRT displays, DEC writers, teletypes, etc. Thirteen baud rates are available from 50 to 9600, either one or two stop bits may be set. Selection is made via rear panel logic switches. Forty readings per second are possible with ASCII coding.

Installation

The interface is installed by removing the top cover of the Model 8500A/8502A and merely plugging the module into the rear slot of the instrument.

NOTE: Isolator option 8500A-08 or 8502A-08A must be installed in place of the jumper pcb when using this interface. The isolator module serially isolates the analog signal processing and conversion from the digital processing, control, display and remote input/output. The maximum allowable difference from guard to logic common is 1000 volts.

Signal Selection

Switches S1 and S2 select the type of signal that the interface will communicate with. Either 20 mA current loop or EIA Standard RS-232B or C voltage loop levels. The switches are located adjacent to the input/output connector J1 (Figure 3), their settings must match the type of terminal to which the interface is connected. See Table 4 for switch settings.

Data Transfer Rates

Baud rates of 50, 75, 110,134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, and 9600 are selectable by logic switches S4 through S7 (Figure 3). The baud rate must be the same as that of the terminal in use. Refer to Table 4 when setting the baud rate switches.

Table 3.

SW	ON	OFF
S1	20 mA	RS-232
S2	RS-232B	RS-232C
S3	1 Stop Bit	2 Stop Bits
S8	Odd Parity	Even Parity

1 = ON 0 = OFF	50	75	110	134.5	150	200	300	600	1200	1800	2400	4800	9600
S4	1	1	0	1	0	1	0	1	0	0	0	0	0
S5	1	1	0	0	0	0	0	0	1	1	0	1	1
S6	0	0	0	1	0	1	1	0	0	0	1	1	1
S7	1	0	0	1	1	0	0	1	0	1	1	0	1

Data Format

In order to provide for a more flexible interface option, three jumpers and a switch are used to select the bits/character and parity generation. When the interface is shipped from the factory, the data format is 8 bits/character, no parity. If desired, the interface may be reconfigured by addition of jumpers, located on the interface module adjacent to the switches S1-S8 on the rear panel.

The number of bits/character are selected by jumpers JP1 and JP2 according to the table below:

BITS	JP1	JP2	
5	1	1	1 = Jumper Installed
6	0	1	
7	1	0	
8	0	0	

Jumper JP3 selects Parity Generation:

JP3 installed = Parity
JP3 removed = No Parity

Switch S8 is used to select even or odd parity:

S8 on = ODD
S8 off = EVEN

NOTE: As stated above the data format when shipped from the factory is 8 bits/character. Most terminals will accept either 7 or 8 bits/character; however, when parity is selected the bits/character is normally set to 7. If this is done, it will not be possible to select binary output format on the Model 8500A since the binary output is an 8 bit byte format; however, many terminals allow 8 bits/character and parity.

Earlier versions of option 8500A-06 were manufactured without jumpers JP1, JP2, and JP3. Switch S8 was installed, but not connected. On these versions, the data format is selectable as well; however, it is accomplished in a different manner. These boards are hard wired for 8 bits/character, no parity generation. To reconfigure, it is necessary to make simple land pattern cuts. These land patterns are located adjacent to the UART 1C, (U9) and include pins 35, 37, 38 and 39. These pins come factory wired to +5V dc. To modify the format, land patterns may be cut and then jumpered to logic common (see Figure 4) according to the charts below. Prior to adding any jumpers to logic common, ensure that the land pattern has been opened between the pin and +5 V dc to prevent a power supply short.

1 = 5 VDC 0 = LOGIC COMMON		**No. of Data Bits**			
U9 Pin No.	**Function**	8	7	6	5
38	NB1	1	0	1	0
37	NB2	1	1	0	1

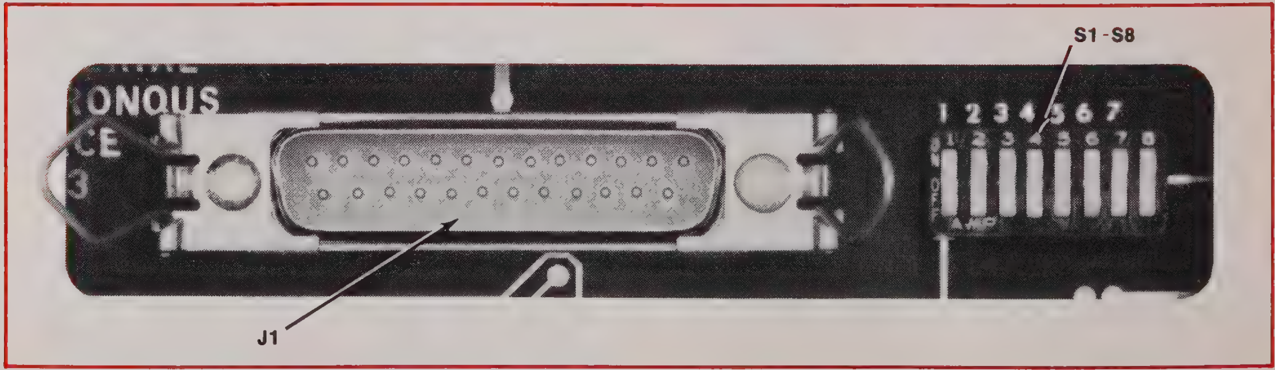


Figure 3. CONNECTOR VIEW BIT SERIAL INTERFACE, OPTION -06

1 = 5 VDC
0 = LOGIC COMMON

U9 Pin No.	Function	Type of Parity None		
		None	Even	Odd
39	EPS	1 0	1	0
35	NP	1 1	0	0

Current Loop Connection

Refer to Figure 5 for 20 mA current loop input/output pin assignments. When connecting to a 20 mA current device note that the 20 mA current sources are provided with this interface, and are inseparable from it. Be certain that sending and receiving circuits to which this interface is connected do not have any other 20 mA current sources. Disconnect any external current sources.

Voltage Level Connection

Because the Bit Serial Interface, Option 8500A-06, is an RS-232C type Z asynchronous interface, only three signal lines are applicable when interfacing to an EIA level RS-232C terminal or controler. They are as follows:

Signal	J1 Pin
Transmitted Data	2
Received Data	3
Signal Ground	7

Option 8500A-06 interface is furnished with a 25 pin female connector, type DB25S (Fluke P N 312579) and connector hood (Fluke P N 320184). A cable is required between the Model 8500A and terminal. If a prewired cable is used a null modem may be implemented. Figure 6 depicts the option 8500A-06 and terminal signal lines that must be connected.

In addition to pins 2, 3, and 7 being connected as shown, the connections depicted by dotted lines may or may not be required by the terminal. Some typical terminals and their conection requirements are shown in Table 5.

NOTE: The terminal used with the option 8500A-06 must use upper case characters. If a mechanical type terminal is used such as a teletyper or T1 at 300 baud or less, the stop bit selector switch S3 should be set for 2 stop bits.

Table 4.

Manufacturer	Model	Jumper Pins
DEC	DL11 VT15 VT50 VT55	None Required
Fluke	1300A	8-20
Micon	KDM-1	None Required
TEC	MINI-TEC	4-5
Texas Inst.	Silent 700	5-6-8-20

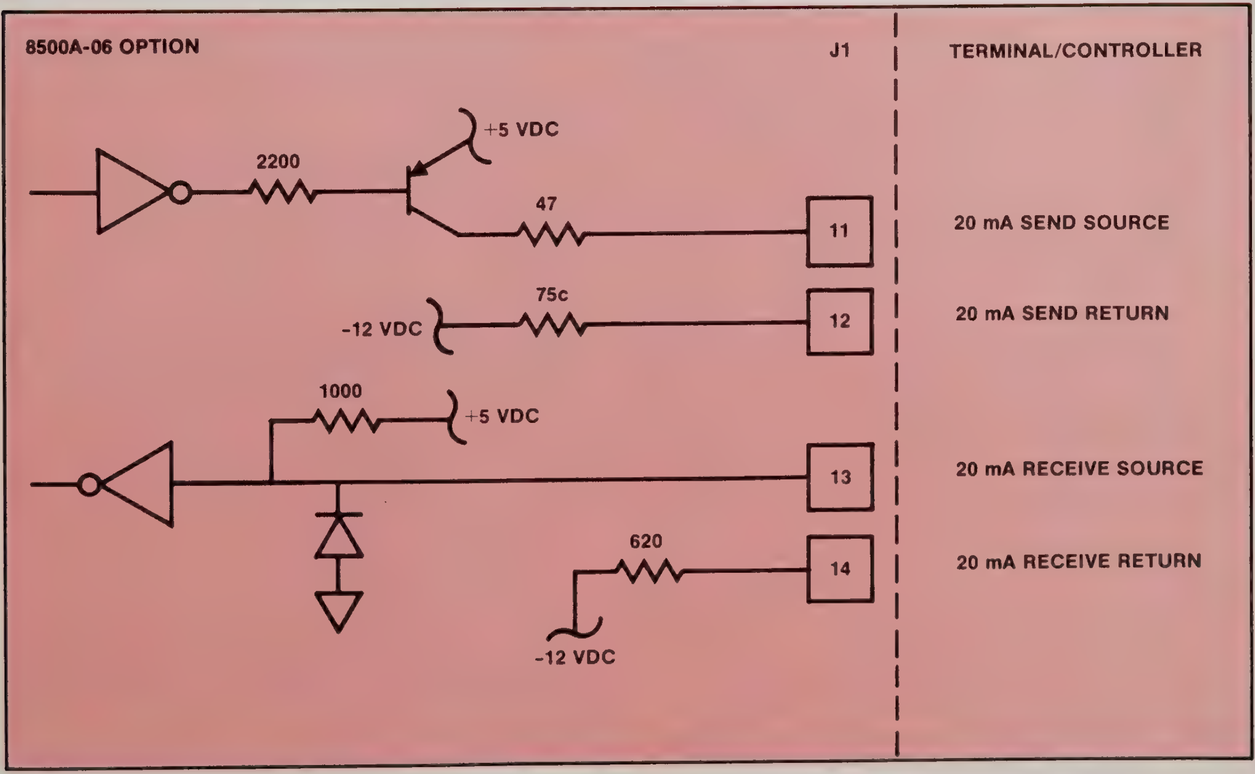


Figure 5. 20 mA CURRENT LOOP CONNECTION

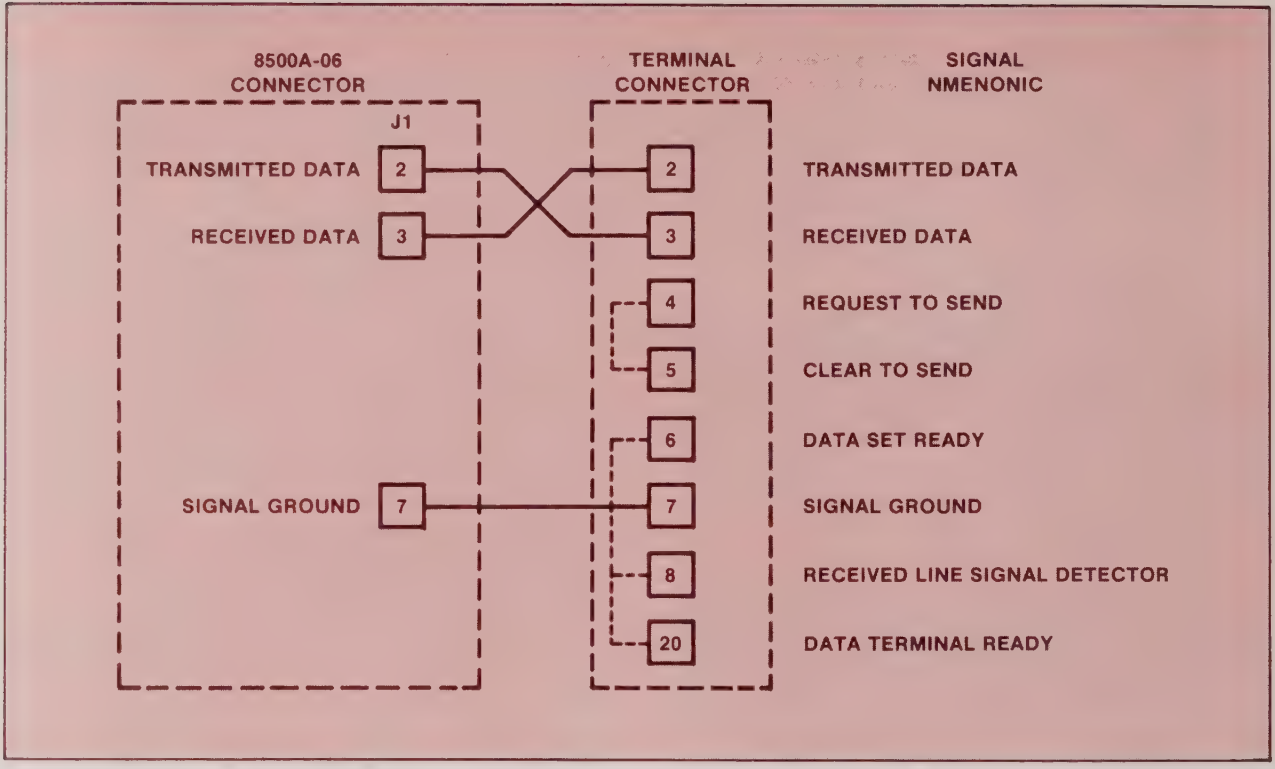

8500A-06
CONNECTOR
TERMINAL
CONNECTOR
SIGNAL
NMENONIC
J1
TRANSMITTED DATA
RECEIVED DATA
SIGNAL GROUND
2
3
7
2
3
4
5
6
7
8
20
TRANSMITTED DATA
RECEIVED DATA
REQUEST TO SEND
CLEAR TO SEND
DATA SET READY
SIGNAL GROUND
RECEIVED LINE SIGNAL DETECTOR
DATA TERMINAL READY

Figure 6. EIA LEVEL CONNECTIONS

PART 4

INTERFACING THE FLUKE 8500A/8502A USING THE PARALLEL INTERFACE

-07, PARALLEL INTERFACE

The Parallel Interface is offered to allow the 8500A/8502A to be interfaced to minicomputer peripheral interfaces, and microcomputer or controller interfaces. Interfacing to a wide variety of these devices is accomplished via a plug-in header called a "personality card". This personality card can be tailored by defining the pins to perform control of the 8500A/8502A through the external device. The -07 provides two ready lines, CIR and COR, and two strobe lines, CIS and COS, that can be wired at either positive true (+5V) or negative true (0V) TTL levels.

The data lines can be grouped into 8 and 16 bit configurations depending upon the width of the external device. Input to the parallel is ASCII only in one or two characters per transfer. The output of the parallel interface can either be ASCII or Binary (2's complement) and can be selected via command codes.

The normal power-up condition of the parallel is eight bit ASCII input and output. Command codes can change this to 16 bit ASCII input (two characters/transfer), 16 bit ASCII output, eight bit Binary output or 16 bit Binary output.

On the 8500, when the front panel remote button is pushed, the unit stops to stimulate it. When the front panel button is pushed on the 8502, the -07 tries to output data (ASCII 8 bit) in a continuous talk only mode (see Case 1 example).

The -07 makes the 8500/8502 very versatile, not only to many types of available computer peripheral interfaces such as the DEC-DRILL and HP-μCKT card, but also for user designed custom interfaces for mini and microcomputers (see case 2).

When creating a personality card, it is first essential to know the external device, and second, understand the -07 connections. A partial schematic and a pin description is provided along with cases to further help in understanding the -07 personality card.

Personality Card Description

Pin #	Mnemonic	Definition
1	COS-B	Data Output Strobe Buffered
2	COS-B	Data Output Strobe Buffered Inverted
3	COS	Data Output Strobe

Description - These pins allow either polarity of strobe from external device to read data from DVM. The trailing edge of these are used to reset the output ready (COR) and tell the DVM Controller to load new data for the external device.

Pin #	Mnemonic	Definition
4	OR 2A	OR GATE 2 input A
5	OR 2B	OR GATE 2 input B
6	OR 2Output	OR GATE 2 output
8	COEN	Control Output Enable
9	DOEN	Data Output Enable

Description (Pins 4, 5, 6) - These pins allow two signals to be OR'd (+ true) or AND'd (− true) for combination of signals for control purposes.

Description (Pins 8, 9) - These pins are used to control when data is output to the external device. They can be controlled by data ready (COR), the data out strobe (COS), or tied to ground for data out always enabled. Valid enable for data out is Low (0V). In the 16 bit mode COEN is used for the low order eight bits and DOEN for the high order 8 bits. In 8 bit mode only COEN need be used.

Pin #	Mnemonic	Definition
11	ILAT	Input MSB Latch
12	SLAT	Input LSB Latch

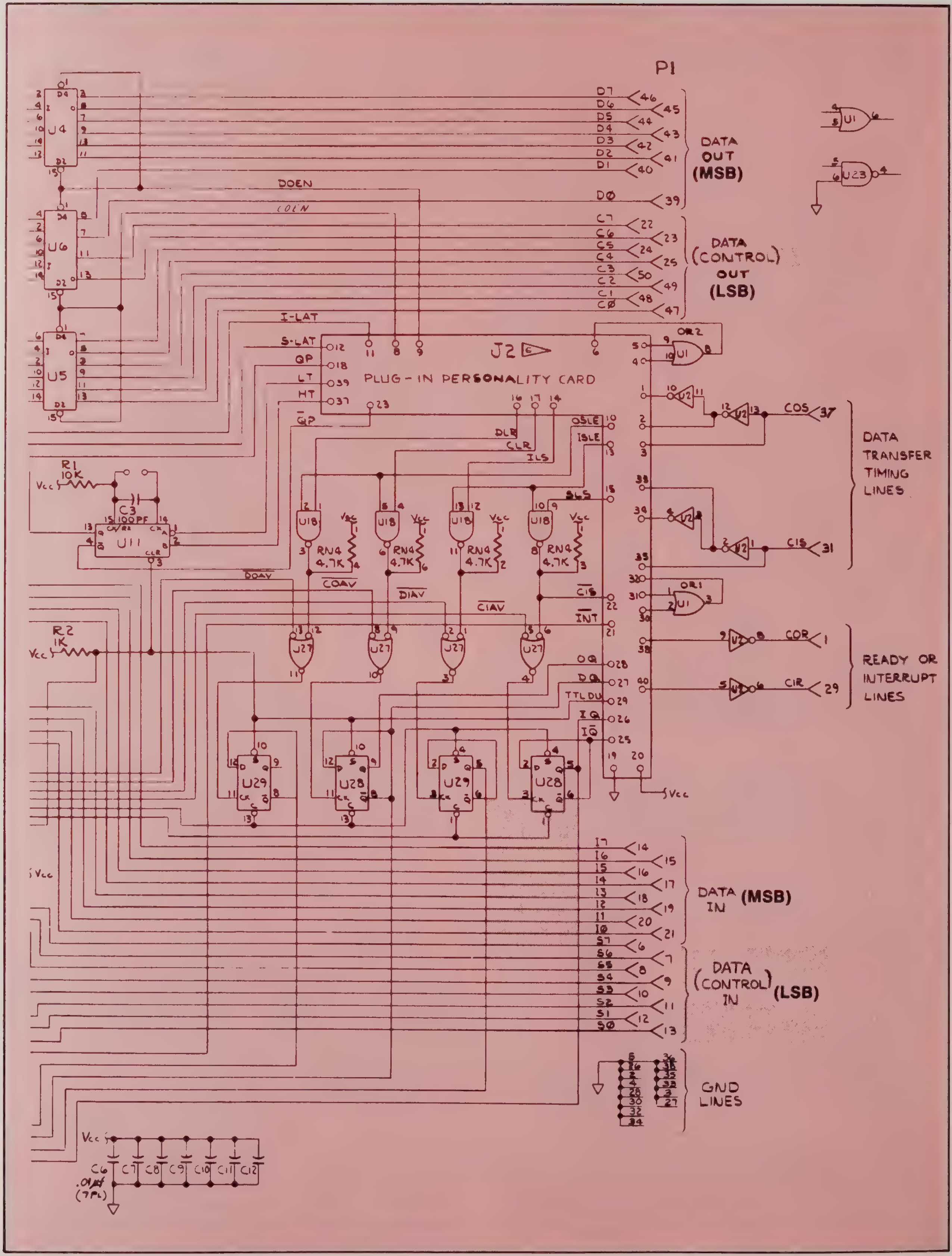
Description - These pins are used to latch data into the -07. Both pins 11 and 12 are used in 16 bit input mode with ILAT being the high order, 8 bits on SLAT being the low order 8 bits. Only SLAT is used in the 8 bit input mode. Data is latched on a negative to positive transition.

Pin #	Mnemonic	Definition
10	OSLE	Output Strobe Latch Enable
16	DLR	Data Output Latch Reset
17	CLR	Control Output Latch Reset

Description - These pins are used to reset the COR output after output data has been read. Resetting the COR allows new data to be loaded. Resetting requires OSLE High and either DLR or CLR High, then either one going low (0V) resets the COR F/F.

Pin #	Mnemonic	Definition
13	ISLE	Input Strobe Latch Enable
14	ILS	Data Input Latch Strobe
15	SLS	Control Input Latch Strobe

Description - These pins are used to control the CIR line for timing of inputting data to the -07. ILS and SLS resets the CIR F/F in the same way as the above COR F/F.


P1
DATA OUT (MSB)
D7 46
D6 45
D5 44
D4 43
D3 42
D2 41
D1 40
D0 39
DOEN
COEN
DATA (CONTROL) OUT (LSB)
C7 22
C6 23
C5 24
C4 25
C3 50
C2 49
C1 48
C0 47
U4
U6
U5
U1
U23
I-LAT
S-LAT
QP
LT
HT
QP
J2
PLUG-IN PERSONALITY CARD
OR2
DATA TRANSFER TIMING LINES
COS 37
CIS 31
OSLE
ISLE
DLR
CLR
ILS
SLS
R1 10K
Vcc
C3 100PF
U11
U18
RN4 4.7K
DOAV
COAV
DIAV
CIAV
CIS
INT
OR1
READY OR INTERRUPT LINES
COR 1
CIR 29
R2 1K
U27
OQ
DQ
TTL DU
IQ
U29
U28
DATA IN (MSB)
I7 14
I6 15
I5 16
I4 17
I3 18
I2 19
I1 20
I0 21
DATA (CONTROL) IN (LSB)
S7 6
S6 7
S5 8
S4 9
S3 10
S2 11
S1 12
S0 13
GND LINES
C6 C7 C8 C9 C10 C11 C12
.01µf (7PL)

PARALLEL INTERFACE (MIS-1171)

Pin #	Mnemonics	Definition
18	QP	High Delay Pulse
23	QP	Low Delay Pulse

Description - These pins are outputs from the delay one shot for extending short pulses or deskewing data. Length can be varied by addition of extra capacitor on U11 across C3. Loaded delay ≈ 600 nS.

Pin #	Mnemonics	Definition
19	GND	Ground
20	Vcc	+5V
29	TTL PU	TTL Pullup
21	INT	Interrupt Clock

Definition - Pin 19, used to tie Inputs Low; Pin 20 used to tie CMOS Inputs High; Pin 29 used to tie TTL Inputs High; Pin 21 provides the interrupt to the DVM controller to input data and requires a negative going pulse of at least 600 ns in duration.

Pin #	Mnemonics	Definition
22	CIS	Clock Input Strobe Inverted

Description - Provides a negative going pulse the width of the external devices data input strobe (CIS). if the pulse is greater than 600 ns this pin is normally connected to INT.

Pin #	Mnemonics	Definition
25	$\overline{IQ}$	Data Input Ready Low
26	IQ	Data Input Ready High

Description - These pins provide either polarity of ready signal to an external device for outputting data to the -07 and are normally connected to pin 40 (CIR) only. On Power UP IQ is high until DVM ready to take data then IQ goes low.

Pin #	Mnemonics	Definition
27	$\overline{DQ}$	Data Output Ready Low
28	DQ	Data Output Ready High

Description - These pins provide either polarity of ready signal to an external device for inputting data from the -07 and are normally connected to pin 38 (COR) only. DQ goes high when a byte of data is ready for the external device to read.

Pin #	Mnemonics	Definition
30	ORA1A	OR gate 1 input A
31	ORA1B	OR gate 1 input B
32	ORA1out	OR gate 1 output
33	CIS B	Control Input Strobe Buffered Inverted
34	CIS B	Control Input Strobe Buffered
35	CIS	Control input Strobe
37	HT	Delay Trigger High
39	LT	Delay Trigger Low

Description (Pins 30, 31, 32) - These pins allow two signals to be OR'd (+ true) or AND'd (− true) for combination of signals for control purposes.

Description (Pins 33, 34, 35) - These pins provide for either polarity of strobe for inputting data to the -07 and giving control of input latches, input ready resets, and DVM interrupt.

Description (Pins 37, 39) - These pins provide either high or low trigger for the delay one shot to generated QP and $\overline{QP}$ pulses. If the low trigger input (39) is used then (37) must be tied high to TTL pu (29). When high trigger (37) is used as the one shot input, then (39) must be tied to ground (19).

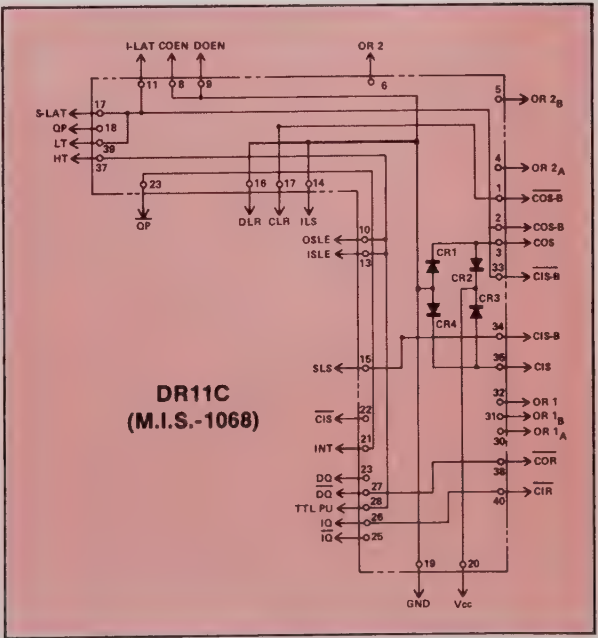
Pin #	Mnemonics	Definition
38	COR	Control Output Ready Inverted
40	CIR	Control Input Ready Inverted

Description - These are used to generate the input (CIR) and output (COR) ready lines.

Prewired Personality Cards

The following are the types of personality cards offered for specific interfaces. Also there is an -07D which allows wiring personality card to custom uses.

-07A FOR DEC DR11C

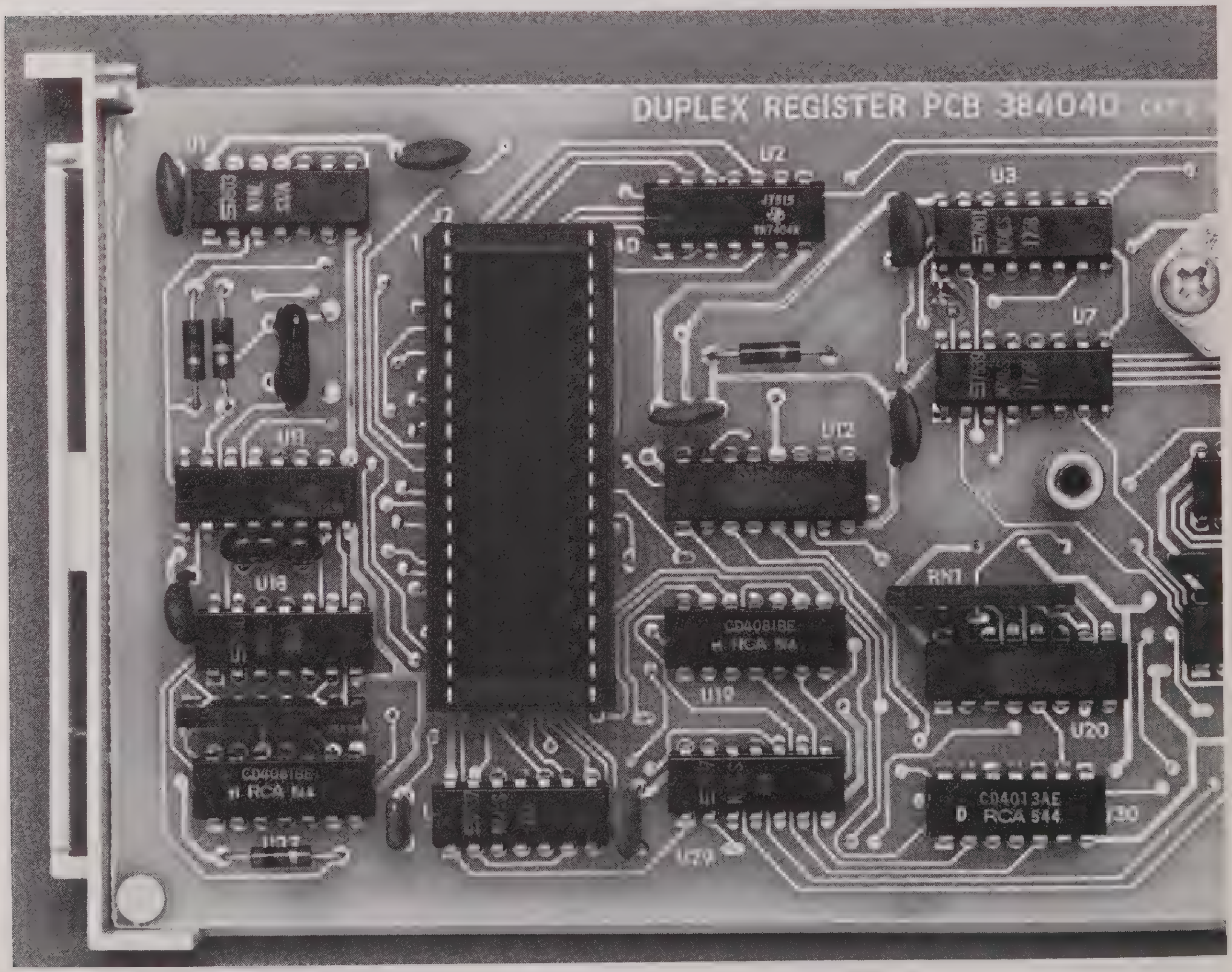


Interface Cable:

-07 Input			DR11C Output
Signal	Pin #	Pin #	Signal
CIS	31	VV	New Data Ready
CIR	29	LL	Request A
I7	14	JJ	DATOT15
I6	15	HH	DATOT14
I5	16	FF	DATOT13
I4	17	BB	DATOT12

I3	18	AA	DATOT11
I2	19	Z	DATOT10
I1	20	X	DATOT9
I0	21	W	DATOT8
S7	6	T	DATOT7
S6	7	R	DATOT6
S5	8	N	DATOT5
S4	9	L	DATOT4
S3	10	U	DATOT3
S2	11	NN	DATOT2
S1	12	K	DATOT1
S0	13	C	DATOT0
GND	32	UU	GND
GND	30	KK	GND
GND	28	MM	GND
GND	26	Y	GND

Signal	**Pin #**	**Signal**	**Pin #**
COS	37	C	Data Transmitted
COR	1	S	Request B
D7	46	M	Data in 15
D6	45	N	14
D5	44	P	13
D4	43	U	12
D3	42	V	11
D2	41	W	10
D1	40	Y	9
D0	39	Z	8
C7	22	CC	7
C6	23	EE	6
C5	24	HH	5
C4	25	KK	4
C3	50	BB	3
C2	49	H	2
C1	48	LL	1
C0	47	TT	0
GND	2	R	GND
GND	38	T	GND
GND	37	UU	GND
GND	4	SS	GND


DUPLEX REGISTER PCB 384040
U1
U2
U3
U7
U12
U18
U19
U20
CD4081BE
RCA 544
CD4013AE
RCA 544
RN1

PERSONALITY CARD LOCATION

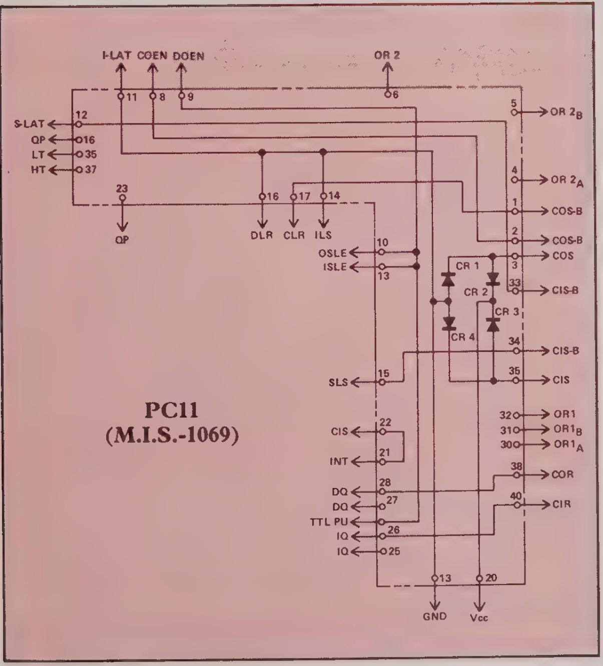
The following is an example of reading speeds attained using a DEC mini and the 8500A/8502A with a -07A Interface.

Sample Rate (SO) – Auto Range – 1V Input-
Line Feed Suppressed (J)
Readings/sec – LSI11-DRV11 Interface

	LINE SYNC		**LINE ASYNC**		**HI-SPEED**	
BITS	8	16	8	16	8	16
ASCII	40	40	60	55	—	—
Binary	115	75	150	115	575	600

Trigger to First Byte of Data			
ASCII	Sync	— 8	— 16
		22 ms	— 22 ms
	Async	— 8	— 16
		14 ms	— 15 ms
Binary	Sync	— 8	— 16
		7 ms	— 11 ms
	Async	— 8	— 16
		5.5 ms	— 6.5 ms
	Hi-Speed	— 8	— 16
		1.4 ms	— 1.4 ms

-07B FOR DEC PC11

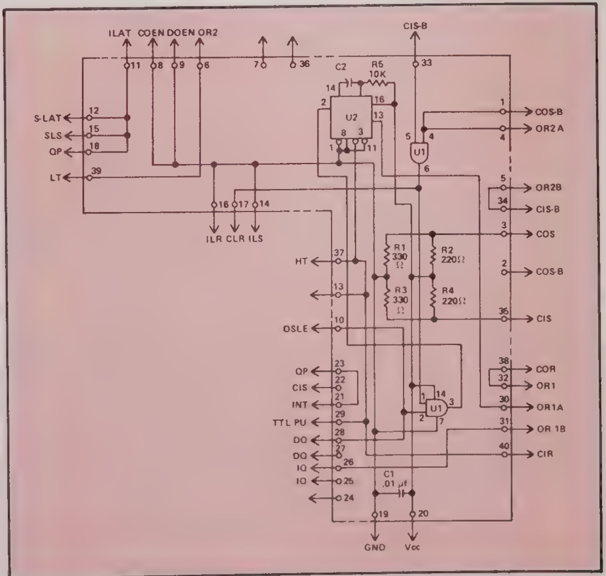

I-LAT
COEN
DOEN
OR 2
11
8
9
6
5
OR 2B
S-LAT
12
QP
16
LT
35
HT
37
23
QP
16
17
14
DLR
CLR
ILS
4
OR 2A
1
COS-B
2
COS-B
3
COS
OSLE
ISLE
10
13
CR 1
CR 2
CR 3
CR 4
33
CIS-B
34
CIS-B
35
CIS
SLS
15
PC11
(M.I.S.-1069)
32
OR1
31
OR1B
30
OR1A
CIS
22
INT
21
38
COR
DQ
28
DQ
27
40
CIR
TTL PU
26
IQ
IQ
25
13
20
GND
Vcc

Interface Cable:

-07 Input		**Punch Output**	
Signal	**Pin #**	**Pin #**	**Signal**
CIR	31H2	I0P4	
S7	6	M2	AC4
S6	7	P2	AC5
S5	8	S2	AC6
S4	9	T2	AC7
S3	10	V2	AC8
S2	11	S1	AC9
S1	12	P1	AC10
S0	13	M1	AC11
GND	28	K2	GND

-07 Output		**Reader Input**	
Signal	**Pin #**	**Pin #**	**Signal**
COR	1	E1	I/O Bus INT L
COS	37	K2	I/O P2
C7	22	M2	I/O Bus 04L
C6	23	P2	I/O Bus 05L
C5	24	S2	I/O Bus 06L
C4	25	T2	I/O Bus 07L
C3	50	V2	I/O Bus 08L
C2	49	S1	I/O Bus 09L
C1	48	P1	I/O Bus 10L
C0	47	M1	I/O Bus 11L
GND	2	D2	GND
GND	36	H1	Rdr OUT tape H

07H = For HP 21MX with 12566 μCKT I/O Card, 9830 with 11202A I/F, or 9825 with 98032A Interface


ILAT
COEN
DOEN
OR2
CIS-B
11
8
9
6
7
36
33
C2
R5
10K
14
2
16
U2
13
8
3
1
11
S-LAT
12
SLS
15
QP
18
LT
39
U1
5
4
6
1
COS-B
4
OR2A
5
OR2B
34
CIS-B
3
COS
16
17
14
ILR
CLR
ILS
HT
37
R1
330 Ω
R2
220Ω
2
COS-B
13
R3
330 Ω
R4
220Ω
35
CIS
OSLE
10
OP
23
CIS
22
INT
21
TTL PU
29
DQ
28
DQ
27
IQ
26
IQ
25
24
U1
38
COR
32
OR1
30
OR1A
31
OR 1B
40
CIR
C1
.01 μf
19
20
GND
Vcc

Interface Card:

-07 Output-Pin # varies by interface card on HP end

Signal	**Pin #**	**Signal**
CIS	31	Device Command or CTL
COS	37	Bit 15*
I6	15	Bit 14
I5	16	Bit 13

* *Control Bit on 21MX - I/O Bit on 9830-9825 to I7. COS to I/O on 9830-9825*

I4	17	Bit 12
I3	18	Bit 11
I2	19	Bit 10
I1	20	Bit 9
I0	21	Bit 8
S7	6	Bit 7
S6	7	Bit 6
S5	8	Bit 5
S4	9	Bit 4
S3	10	Bit 3
S2	11	Bit 2
S1	12	Bit 1
S0	13	Bit 0
GND	30,32, 36,38	GND

COR	1	Input Device Flag or FLG
D7	46	Bit 15
D6	45	Bit 14
D5	44	Bit 13
D4	43	Bit 12
D3	42	Bit 11
D2	41	Bit 10
D1	40	Bit 9
D0	39	Bit 8
C7	22	Bit 7
C6	23	Bit 6
C5	24	Bit 5
C4	25	Bit 4
C3	50	Bit 3
C2	49	Bit 2
C1	48	Bit 1
C0	47	Bit 0
GND		
2,3,4,5		
24		
GND		

Interface Examples for -07 Personality Cards

The following cases are presented to better illustrate the versatility of the -07 to meet interface requirements and provide a step-by-step look into creating a personality card for a given I/O.

CASE 1

Need interface to a 9 track Magnetic Tape Unit to provide hard-copy data for further data reduction. The Tape Unit has the following criteria for interfacing:

Inputs =	Write Data Strobe =	minimum pulse < 2 μsec Data written 0.5 μsec after leading edge negative true.
	Data In =	D0 - D7
Outputs =	Write Ready Status =	Unit ready for taking data negative true
	Memory Busy =	Memory full-cannot take more data-negative true
Analysis of Tape Unit =		Before sending data to the tape unit Write Ready Status must be true (low) and Memory Busy must be false (high). When data is available from -07 interface, a Write Data Strobe must be issued at greater than 2 μsec.
Analysis of -07 =	Data Output Only =	Talk Only Mode of 8502A used. Not available on 8500A.

The -07 has two inputs (CIS and COS) and two outputs (CIR and COR). To output data to the Tape Unit, the Write Ready Status must be low and the Memory Busy must be high.

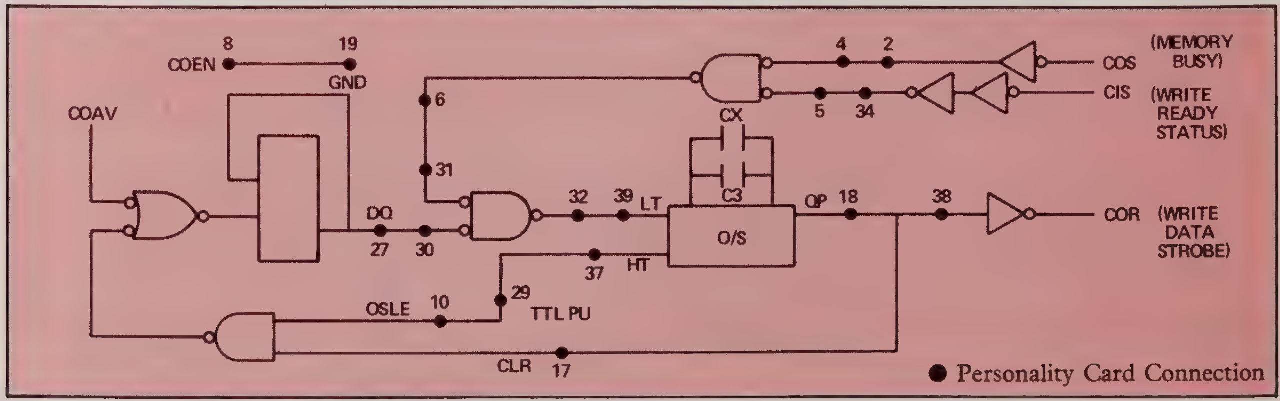
INPUT-OUTPUT CABLE CONNECTIONS

Tape Unit	8500A-07
Write Ready Status	CIS
Memory Busy	COS
Write Data Strobe	COR
D0	C0
D1	C1
D2	C2
D3	C3
D4	C4
D5	C5
D6	C6
D7	C7

To generate Write Data Strobe (COR), the following conditions must be met:

Memory Busy	False	High	COS
Write Ready Status	True	Low	CIS
Data Available (-07)	True	Low	DQ

Therefore: $\mathrm{COS} \bullet \overline{\mathrm{CIS}} \bullet \overline{\mathrm{DQ}} = \overline{\mathrm{COR}}$



Since Write Data Strobe ($\overline{\text{COR}}$) must be greater than 2 µsec. One shot U11 (74LS123) is used with a value selected for Cx of worst case > 2 µsec (Cx≥600 pf). COEN (8) is grounded since data doesn't need strobing out.

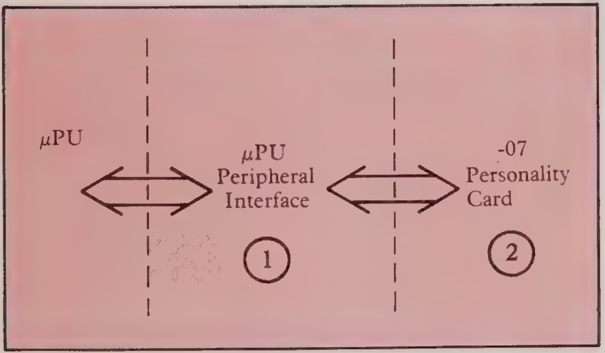
By selecting Talk Only (pushing the Remote button) on the 8502A, as long as Memory Busy (COS) is false (high) and Write Ready Status (CIS) is true (low) the -07 will output ASCII data to the Mag Tape Unit.

CASE 2

To add the -07 8500A/8502A DVM to a Microprocessor Bus.

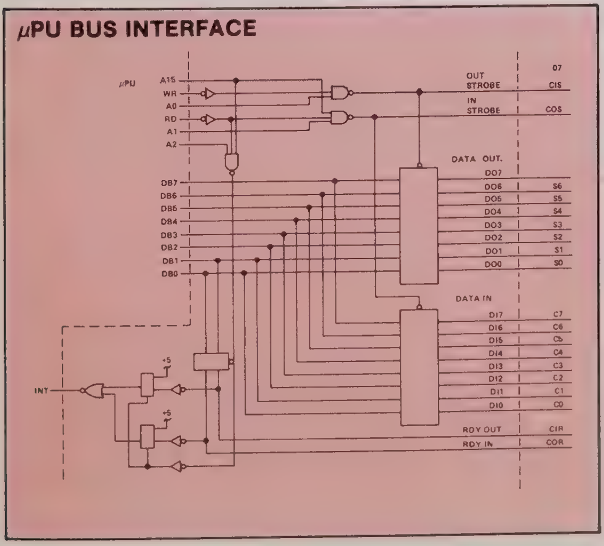
This requires a piece of external hardware but because of the -07, the I/O becomes relatively simple.

The µPU generates a READ and a WRITE whenever the Bus is being used. The µPU has the capability of 64K of memory but only 32K will be used. Thus the high order address bit A15 can be used for memory mapped I/O. Whenever A15 is active, data is being transferred to a peripheral hooked to the eight bit µPU Bus.


µPU
µPU Peripheral Interface
-07 Personality Card
①
②

Items 1 and 2 must be done to interface the µPU to the DVM. Item 1 can be done first because of the flexibility of inputs to the -07. The following is just one of many examples for a peripheral interface.

µPU BUS INTERFACE


µPU
A15
WR
A0
RD
A1
A2
DB7
DB6
DB5
DB4
DB3
DB2
DB1
DB0
INT
+5
+5
07
OUT STROBE
CIS
IN STROBE
COS
DATA OUT.
DO7
DO6
DO5
DO4
DO3
DO2
DO1
DO0
S6
S5
S4
S3
S2
S1
S0
DATA IN
DI7
DI6
DI5
DI4
DI3
DI2
DI1
DI0
C7
C6
C5
C4
C3
C2
C1
C0
RDY OUT
CIR
RDY IN
COR

The hook-ups to the -07 would be as follows

CABLE:	
OUTSTROBE	CIS (must be greater than 1 µs)
OUTPUT READY	CIR
IN STROBE	COS
INPUT READY	COR
DO7-DO0	S7-S0
DI7-DI0	C7-C0

OUTSTROBE is a pulse ≥ 1 µsec of negative (true) duration. The -07 must latch the data before the OUTSTROBE goes back high. To accomplish this the one shot is used with 500 ns pulse to load data.

Personality Card Jumpers

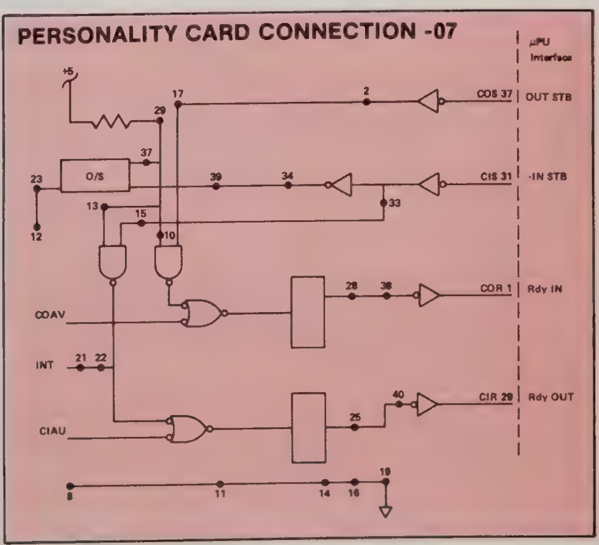
34 to 39 = For trigger input generate DATA LATCH
37 to 29 = Pull up
23 to 12 = Latch data
33 to 15 = Reset Ready Out
13 to 29 = Pull up
22 to 21 = Interrupt DVM
14 to 19 = Pull down
11 to 19 = Pull down
25 to 40 = Generates CIR so new data can be input to DVM

The above connections take care of inputting data into the DVM. For the DVM to output data, the following connections must be made.

28 to 38 = Generates COR telling µPU data available
2 to 17 = Reset COR
8 to 19 = Output data always enabled
10 to 29 = Pull up
16 to 19 = Pull down

This now allows the µPU to provide stimulus to the DVM and for the DVM to respond with measurement data as called out by the µPU.

PERSONALITY CARD CONNECTION -07


µPU Interface
+5
17
29
2
COS 37
OUT STB
37
O/S
23
39
34
CIS 31
-IN STB
33
13
15
12
10
28
38
COR 1
Rdy IN
COAV
INT
21
22
40
CIR 29
Rdy OUT
25
CIAU
19
8
11
14
16

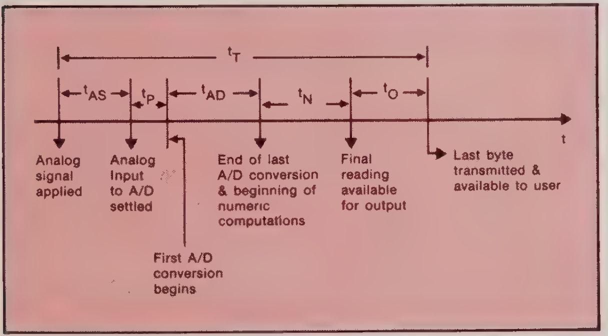
8500A TIMING DATA

PART 5

CONVERSION RATE PARAMETERS:

1. Analog settling time, t_{AS}
2. Trigger processing time, t_P
3. A/D Conversion time, t_{AD}
4. Numeric modifications and conversions time, t_N
5. Output reading time, t_o

Each of the above parameters will be discussed separately and example calculations will be given for several of the more common modes of system usage.

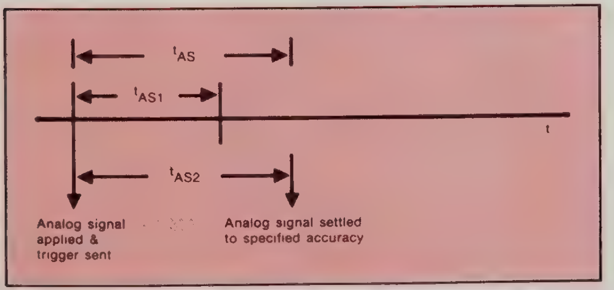


tT
tAS
tP
tAD
tN
tO
t
Analog signal applied
Analog Input to A/D settled
End of last A/D conversion & beginning of numeric computations
Final reading available for output
Last byte transmitted & available to user
First A/D conversion begins

The total time t_T is the time to setup a reading, measure it, and output the reading. The reading speed is then given by $1/t_T$ in readings/sec.

$t_T = t_{AS} + t_{AD} + t_N + t_o$

ANALOG SETTLING TIME, t_{AS}



tAS
tAS1
t
tAS2
Analog signal applied & trigger sent
Analog signal settled to specified accuracy

$t_{AS} =$

MAX (t_{AS1}), t_{AS2})

$t_{AS1} =$

Filter settle timeout (programmable as F2, F3 modes)

= 0 filter timeout disabled (F, F0, F1 modes)
= 0 filter bypass
50 ms fast filter, filter timeout enabled (F3 mode)
500 ms slow filters, filter timeout enabled (F2 mode)

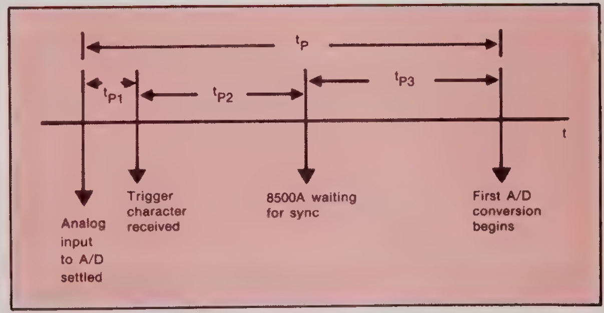
$t_{AS2} =$

Filter Mode	Step Input to 0.01% of Change	Step Input to 0.001% of Change
Bypassed <100k Source Resistance	2 ms	20 ms
Filter Out (Fast)	40 ms	50 ms
Filter In (Slow)	400 ms	500 ms

The above table indicates the time required for the filter output to settle the given accuracy.

The t_{AS2} delay must be provided by the user if desired.

TRIGGER PROCESSING TIME, t_P



tP
tP1
tP2
tP3
t
Analog input to A/D settled
Trigger character received
8500A waiting for sync
First A/D conversion begins

$t_{P1} =$

Function of user timing (may be negative in order to overlap settling with 'trigger processing time'). Thus T_P may range from minus min (t_{AS}, t_{P2}) to as large as the user desired.

$t_{P2} =$

Trigger processing time from the time the trigger character is received to the time the 8500A begins waiting for line synchronous interrupt. T_{P2} is dependent on the I/O interface that is installed.

I/O Interface:

Duplex Register:
Hi-Speed Mode: 0.089-097 ms
Continuous Mode: 0.466 ms
Triggered Mode: 1.121-1.138 ms, 8-bit and 1.422-1.442 ms, 16-bit*

IEEE-488:

Continuous Mode: 0.466 ms
Triggered Mode: 1.131 to 1.150 ms

Bit Serial: (no echo, i.e. YO Mode)

Continuous Mode: .466 msec
Triggered Mode: 1.100 to 1.118

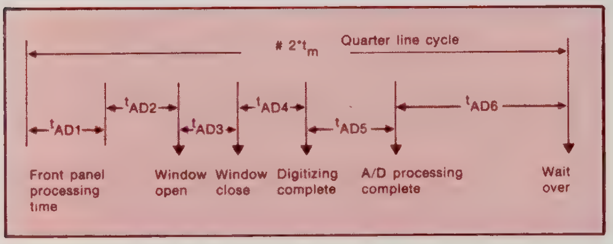
t_{P3} =

Time for which the 8500A is waiting for line synchronization.

0.000 ms, non-line synchronous mode
0.600-4.767 ms, line synchronous mode (60 Hz)
0.600-5.600 ms, line synchronous mode (50 Hz)

* *Assumes '?' in upper byte, null in lower byte.*

A/D CONVERSION TIME, T_{AD}



# 2*t_m
Quarter line cycle
t_AD1
t_AD2
t_AD3
t_AD4
t_AD5
t_AD6
Front panel processing time
Window open
Window close
Digitizing complete
A/D processing complete
Wait over

t_{AD} =

$(n*t_{ADC}) - t_{AD6}$; where n = number of samples

t_{ADC} =

$t_{AD} + t_{AD2} + t_{AD3} + t_{AD4} + t_{AD5} + t_{AD6}$

t_{AD} =

Front panel display update and switch reading time

0 μs for line asynchronous
85 μs for line synchronous without display
250 μs for line synchronous with display

t_{AD2} =

20-23 μs beginning of A/D conversion to opening of analog sample window

t_{AD3} =

337-358 μs window open to close and remainder latched in A/D converter

t_{AD4} =

823-903 μs remaining digitizing time

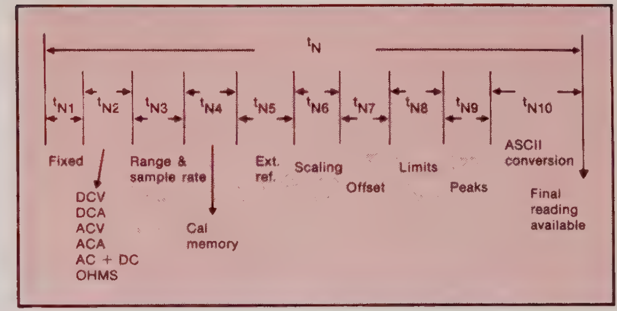
t_{AD5} =

A/D processing completion:
318 μs line asynchronous without autoranging
457 μs line asynchronous with autoranging
48 μs line synchronous

t_{AD6} =

0 for line asynchronous
$2*t_m - (t_{AD1} + t_{AD2} + t_{AD3} + t_{AD4} + t_{AD5} +)$ for line synchronous # where t_m = 2.083 ms at 60 Hz)(i.e. 1/[8*line frequency)]

NUMERIC MODIFICATION AND CONVERSION TIME, t_N



t_N
t_N1
t_N2
t_N3
t_N4
t_N5
t_N6
t_N7
t_N8
t_N9
t_N10
Fixed
DCV
DCA
ACV
ACA
AC + DC
OHMS
Range & sample rate
Cal memory
Ext. ref.
Scaling
Offset
Limits
Peaks
ASCII conversion
Final reading available

Definition of Times

$t_N = (t_{N1} + t_{N2} + t_{N3} + t_{N4} + t_{N5} + t_{N6} + t_{N7} + t_{N8} + t_{N9} + t_{N10})*\text{fsync}$

t_{N1} =

Fixed overhead for any reading 1.47 ms

t_{N2} =

Function type computation time

DCV	0.93 ms	
DCA	0.15 ms	
ACV	0.03 ms	
ACA	0.03 ms	
AC + DC	5.19 ms	
FASTOHMS	6.13 ms	
OHMS	50 Hz	60 Hz
Range 6 & 7	74.5	67.0 ms
Range 0 to 5	120.0	106.2 ms
In autoranging add	0.6	0.6 ms
If not in external reference for filter timeouts	50 Hz	60 Hz
Slow	605.0	504.2 ms
Fast	65.0	54.2 ms
Bypass	15.0	12.8 ms

t_{N3}fl =

Range and sample rate adjustments

a) if in sample rate, S0 to S7 use value from table N1

b) if in sample rate, H0 to H9
$t_{N3} = 0.64 + 0.16*n + z$ ms;
where 2_{N+7} = sample rate (i.e., H2 = sample rate 2^{10}, therefore n = 3) and where z = value from table N1 for sample rate 7 by appropriate range

c) if in dc V range 3 or 4 add 0.83 ms

t_{N4} =

Calibration Memory

if not installed	0.00 ms
if correction inhibited	0.52 ms
if no correction is stored	1.51 ms
if correction stored	5.82 ms

t_{N5} =

External Reference Mode

Filter	50 Hz	60 Hz
Slow	762.9	642.0 ms
Fast	222.9	192.0
Bypass	172.6	150.0 ms

t_{N6} =

Scaling Mode 5.20 ms

t_{N7} =

Offset Mode 0.85 ms
if in ACV or DCV 1.47 ms

t_{N8} =

Limits Mode 0.43 ms
if in ohms 43.2 ms

t_{N9} =

Peaks Mode 0.54 ms

t_{N10} =

ASCII Conversion 6.10 ms

fsync =

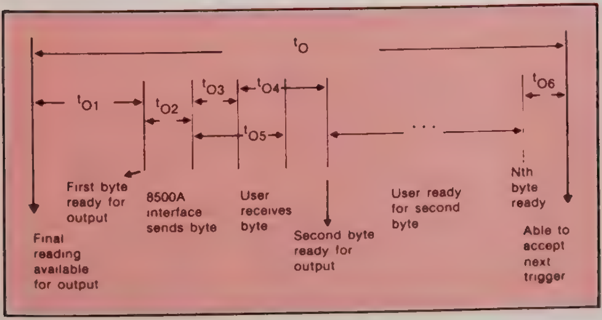
Line synchronous interrupt processing time factor
1.01 line asynchronous mode
1.36 line synchronous mode

Table N1

	RANGE	SAMPLE RATE							
		0	1	2	3	4	5	6	7
DCA, DCV ACA, ACV	0	0.28	0.41	0.54	0.67	0.80	0.93	1.06	1.19
	1	0.15	0.01	0.15	0.28	0.41	0.54	0.67	0.80
	2	0.55	0.42	0.29	0.15	0.01	0.15	0.28	0.41
	3	0.95	0.80	0.68	0.55	0.42	0.29	0.15	0.01
	4	1.34	1.21	1.08	0.95	0.80	0.68	0.55	0.42
OHMS	0	0.01	0.15	0.28	0.41	0.54	0.67	0.80	0.93
	1, 2, 3, 4	0.42	0.29	0.15	0.01	0.15	0.28	0.41	0.54
	5, 6, 7	0.80	0.68	0.55	0.42	0.29	0.15	0.01	0.15

All times in ms

OUTPUT READING TIME, To



t_O
t_{O1}
t_{O2}
t_{O3}
t_{O4}
t_{O5}
t_{O6}
. . .
First byte ready for output
8500A interface sends byte
User receives byte
User ready for second byte
Nth byte ready
Final reading available for output
Second byte ready for output
Able to accept next trigger

t0 =

$t_{01} + (t_{02} + \text{Mac}\ (t_{03} + t_{05}))*N + t_{06}$

t01 =

Output routine initialization time

t_{02} =

Time to load and send data byte (2 bytes if 16-bit duplex register mode)

t_{03} =

Hardware interface byte transmission time

t_{04} =

Data byte acceptance time (user configuration dependents)

t_{05} =

Time to prepare next byte for transmission

t_{06} =

Time from transmission of last byte till 8500A able to accept next trigger.

N =

Total number of bytes output (or number of 2 byte transfers for 16-bit duplex register)

t_{01} =

0.187 ms ASCII
0.075 ms Binary
0.083 ms Limits – ASCII
0.080 ms Limits – Binary

t_{02} =

0.179 ms (IEEE-488)
0.078 ms (Duplex Register – 8 bit)
0.156 ms (Duplex Register – 16 bit)
0.085 ms (Bit Serial)

t_{03} =

0.032 ms (IEEE-488)
0.017 ms (Duplex Register)
$1.0\text{x}10^4 \div b$ ms (Bit Serial) Where b = baud rate (e.g., 9600) with 1 stop bit
$1.1 \times 10^4/b$ ms (Bit Serial) Where b = baud rate (e.g., 110) with 2 stop bits

t_{05} =

0.300 ms ASCII (worst case)
0.035 ms Binary
0.035 ms Limits

t_{06} =

0.200 ms (worst case)

N =

1 Limits-Binary (1 for 16-bit mode)
5 Binary (3 for 16-bit mode)
2, 3 or 4 Limits-ASCII (2 or 3 for 16-bit mode)
13 or 14 ASCII (7 for 16-bit mode)

SAMPLE COMPUTATIONS

The following examples are sample calculations used to illustrate the steps necessary to determine the total time required to take a single triggered reading. That is from the time a trigger is sent till the next trigger can be sent. The end result of each calculation will be 1/$_t$T (i.e. the number of readings per second).

A few assumptions have been made and need explanation. The analog settling time ($_t$AS) is considered to be zero, since except in ohms or external reference (or in systems where the user switches from one source to another). The signal is constantly applied to the filter and so is completely settled during the powering on period. Those times which are user dependent will be taken as zero, however in reality they can be quite significant. The time '$_t$P1' is the time the user's system takes to generate and send the trigger character (for time critical applications it can be overlapped with the analog settling time). The time '$_t$04' is the time the user's system takes to receive and process the next byte. In terms of degrading the maximum number of readings per second the 8500A will be able to transmit '$_t$04' can be significant.

One further statement should also be made. Some of the timing data is very precise (particularly the A/D time), but especially for the numeric conversion and display time. The worst case has always been taken, so it is highly likely that the user will see some small increase in speed for a particular application over the times calculated from this paper.

DCV

1.3V on input, range 2, sample/rate S0, limits mode, ASCII output to BIT SERIAL at 2400 baud, single trigger, line asynchronous

t_T =
$t_{AS} + t_P + t_{AD} + t_N + t_O$

t_{AS} =
O

t_P =
0.00 + 1.118 + 0.00 = 1.118 ms

t_{AD} =
1*(0.00 + 0.023 + 0.358 + 0.903 + 0.318) -0.0 = 1.60 ms

t_N =
(1.47 + 0.93 + 0.55 + 0.00 + 0.00 + 0.00 + 0.00 + 0.43 + 0.00 + 6.10)*1.01 = 9.57 ms

t_O =
0.187 + [0.085 + max (1.1 x 10^4/2400 + 0.00, 0.30)]*14 + 0.200 = 64.64 ms

t_T =
76.99 ms

1/t_T =
13 readings per second

DCV

300 mV on input, range 0, sample/rate S0, filter bypass, ASCII output to BIT SERIAL module at 9600 baud, single trigger, line asynchronous

t_T =
$t_{AS} + t_P + t_{AD} + t_N + t_O$

t_{AS} =
O

t_P =
0.00 + 1.118 + 0 = 1.118

t_{AD} =
1*(0.00 + 0.023 + 0.358 + 0.903 + 0.318) -0.0 = 1.60

t_N =
(1.47 + 0.93 + 0.28 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00 + 6.10)*1.01 = 8.87 ms

t_O =
0.187 + [0.085 + max (1.1*10^4/9600 + 0.00, 0.300)]*14 + 0.200 = 17.62

t_T =
29.21 ms

1/t_T =
34 readings per second

DCV

1.00000V input, range 2, sample/rate S0, filter bypass, binary output to IEEE-488 I/F single trigger, line asynchronous, no other modifiers

t_T =
$t_{AS} + t_P + t_{AD} + t_N + t_O$

t_{AS} =
O

t_P =
0 + 1.15 ms + 0 = 1.15

t_{AD} =
1*(0.00 + 0.023 + 0.358 + 0.903 + 0.318) -0.0 = 1.60

t_N =
(1.47 + 0.93 + 0.55 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00)*1.01 = 2.98 ms

t_O =
0.075 + [0.179 + max (0.032 + 0.000, 0.035)]*5 + 0.200 = 1.35 ms

t_T =
7.08 ms

1/t_T =
141 readings per second

Ohms

10 kΩ on input, range 4, sample/rate S2, filter bypass, ASCII output to IEEE-488 I/F, single trigger, line synchronous

t_T =
$t_{AS} + t_P + t_{AD} + t_N + t_O$

t_{AS} =
O

t_P =
$0.00 + 1.15 + 4.77 = 5.92$ ms

t_{AD} =
$4*(0.250 + 0.023 + 0.358 + 0.903 + 0.048 + 2.585) - 2.585 =$
14.080 ms

t_N =
$(1.47 + 67.0 + 39.2 + 12.4 + 12.4 + 0.15 + 6.10)*1.36=$
171.80 ms

t_O =
$0.187 + [0.179 + \max(0.32 + 0.0, 0.300)]*14 + 0.200 =$
7.09 ms

t_T =
198.9 ms

$1/t_T$ =
5 readings per second

Auto Ranging

When the 8500A is in the auto ranging mode and for any reason the reading becomes greater than the maximum value for a given range or less than 3/32 of the maximum value for that range (excpet in the lowest range) range changing will occur. If the reading value is within the above limits this section can be ignored, otherwise the total time the 8500A will take to obtain a valid reading and output it can be computed from the following data.

Then time 't_{TOTAL}' then is; $t_{TOTAL} = t_{AR} + t_T$

t_{AR} =
$t_{AR1} + (2n + 3)*t_m + t_{FT} + t_{U/D}*z$

n =
number of samples per reading

t_m =
time to take one sample
4.167 ms line synchronous - 60 Hz
5.000 ms line synchronous - 50 Hz
1.741 ms line asynchronous

t_{FT} =
filter timeout for both line synchronous & line asynchronous

60 Hz	50 Hz
210.5 ms	252.5 ms slow
22.9 ms	27.5 ms fast
12.5 ms	15.0 ms bypass

$t_{U/D}$ =
time to uprange (or downrange) from upranging and downranging chart

z =
number of range changes

t_{AR1} =
0.36 ms fixed overhead

Upranging And Downranging

All times in ms.

		60 Hz	50 Hz
ACV	0.27+	108.44	130.11
ACA	0.19		
DCV	0.39+	27.08	32.50
DCA	0.32		
OHMS			
Range 6 and 7 line synchronous	14.03+	75.00	90.00
line asynchronous	14.03+	68.74	78.74
Range 0 to 5 line synchronous	15.51+	137.50	165.00
Line asynchronous	15.51+	124.98	142.48
Add for filter			
Slow		504.17	605.00
Timeouts			
Fast		54.17	65.00
Bypass		12.50	15.00

NOTE

In line asynchronous mode samples are taken asynchronous but filter timeouts are still taken synchronous to the line frequency.

The maximum value for each function and for each range is the following.

FUNCTION	RANGE	MAXIMUM VALUE
DCV	0	312.5 mV
	1	2.5V
	2	20V
	3	160V
	4	1200V
ACV	1	2.5V
	2	20V
	3	160V
	4	1000V
DCA & ACA	0	312.5 μA
	1	2.5 mA
	2	20 mA
	3	160 mA
	4	1.28A
OHMS	0	31.25Ω
	1	250Ω
	2	2 kΩ
	3	32 kΩ
	4	256 kΩ
	5	4.096 MΩ
	6	32.768 MΩ
	7	262.144 MΩ

PART 6

EXTERNAL TRIGGER

The 8502A has the capability of being externally triggered with or without a remote interface. To get into the External Trigger mode the trigger button on the front panel can be activated or a remote device can command the 8502A to go into External Trigger mode. When External Trigger is enabled, each trigger input causes the 8502A to take readings and either interrupt or transmit when completed. The trigger in effect replaces the "?" software command. (See Section 1 on programming External Trigger.)

The trigger input is brought into the 8502A via a BNC connector on the Rear Panel. The outside of the BNC is at interface common. There should be no more than 10V between the outer connector and earth ground.

Either positive or negative trigger pulses may be accepted although factory wiring is for negative triggers. (To change see Section 608A of the 8502A Manual.) Input levels are wired for 4.3V (min. high) and 0.7V (max. low) and pulse duration should be greater than 10 μsec.

The time between trigger edge and first A/D conversion (not including filter timeouts or programmed delays) is as follows.

1.	Line Synchronous Mode	1 to 6 msec
2.	Asynchronous Mode	.8 to .9 msec
3.	High Speed Mode (option -05 or -07 installed)	114 ± .5 μsec

Another External Trigger will not be accepted until processing of the previous reading has been completed. This time depends on samples/reading, delays, timeouts, etc. as expressed earlier in this section.

PART 7

REAR ANALOG INPUT

Analog Connections Using Option -16 or -17

The 8500A with Option -17 or the 8502A with Option -16 or -17 allows the user to connect Analog Signal Inputs to the rear panel of the DVMs.

The Option -17 is Parallel Input to the Front Panel Binding Posts while the Option -16 (8502A only) allows Front/Rear Switched Inputs by manual operation from the Front Panel.

Connections:

Pin #	**Signal**
A	Guard
B	Source Low
D	Chassis
E	Input Low
K	Ext Ref Hi
L	Ext Ref Lo
R	Ohms Guard
S	Input Hi
X	Source Hi

Mating Connector*:
  ELCO # 00-8016-020-000-703/Fluke # 369213
Connector Pins*:
  Solder: ELCO # 217-60-8017-05-13/Fluke # 369298
  Wirewrap: ELCO # 218-60-8017-13/Fluke # 369272
  Crimp: ELCO # 000-60-8017-03-13/Fluke # 369280

**Included with -16 or -17 Options*

APPENDICES

APPENDIX A

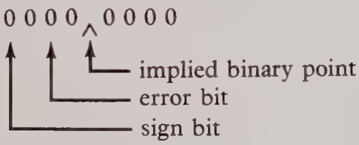
HIGH SPEED READING MODES

At 500 readings/second, most of the numeric processing done by the 8500A/8502A must be dropped. The use of the high speed mode would be appropriate in the following system environments.

1. Systems with a very fast processor which can implement any necessary conversions in real time.
2. Storage of readings very quickly in real time and delaying numeric conversions until after a certain number of readings have been accumulated.
3. Applications that require no direct numeric conversions such as counting the number of zero crossings of an input signal or tallying large deviations from a nominal value.

Data will always be in the three byte (binary two's complement notation) format. The first byte of data contains an implied binary point at its midpoint and implied scale factor of 10. The first byte also contains the sign and error bits.

byte 1



If the sign bit is equal to "1" then the reading is negative and then all three bytes must be complemented (2's complemented) before conversion. If the error bit is equal to the complement of the sign bit then an error has occured. This is easy to varify since the conversion of the three bytes equals 20 (+ or −) or greater then there is an error.

The second and third bytes have no unique significance.

byte 2
00000000
byte 3
00000000

Examples

$$\underbrace{0001_{\wedge}0100}_{1.25} + \underbrace{00000000}_{0} + \underbrace{00000000}_{0}$$

Reading (RAD) = 1.25 • 10 = 12.5V

$$\underbrace{1111_{\wedge}0111}_{\text{Sign bit} = 1} \quad 10111111 \quad 11111111$$

Form 2's complement

$$\underbrace{0000_{\wedge}1000}\ \underbrace{0100000}\ \underbrace{00000001}$$

−(0.5 + 0.015625 + 0.000001)

Reading (RAD) = −0.515626 • 10
−5.15626 V

$$\underbrace{1101_{\wedge}1111}\ \underbrace{11111111}\ \underbrace{11111111}$$

−(2.0 + 0 + 0.000001)

Reading (RAD) = −2.0 . 10 = −20V

ERROR Condition

The 16 bit format for a HI-SPEED reading is

BYTE 1	BYTE 2
—	BYTE 3

Note

It is not possible to make range, function, control, memory or modifier changes while in this mode, nor are any modifier modes applied to the reading; i.e., offset, V dc zero, cal memory factors, scaling, etc. are ignored.

The hi-speed mode may be aborted at any time by transmitting any character other than a "?" for a trigger. The character sent will be ignored, however, it will cause the instrument to leave the hi-speed mode.

DC Volts

To obtain the true reading for DC Voltage the RAD value must be multiplied by a scale factor for the range of the instrument.

True Reading (RT) = RAD • Scale

Table A-1

Range	Scale
R0 (100 mV)	1/64
R1 (1V)	1/8
R2 (10V)	1
R3 (100V)	8
R4 (1000V)	64

For the above examples

RAD = 1.25V & 100 mV Range
RT = 1.25/64 = 0.019531V
RAD = −5.15626 & 100V Range
RT = −5.15625 • 8 = −41.2501V

AC Volts

To obtain the true reading for AC Voltages the V_{AD} value must be multipled by a scale factor for the range of the instrument.

True Reading $R_T = | R_{AD} |$ x Scale

Table A-2

Range	Scale
R1 (1V)	1/8
R2 (10V)	1
R3 (100V)	8
R4 (1000V)	64

DC Current

True Reading $R_T = -R_{AD} \bullet$ Scale where Scale and the units of R_t are given in Table A-2 for each range.

Table A-3

Range	Scale	Units
R0 (100 μA)	1/64	mA
R1 (1 mA)	1/8	mA
R2 (10 mA)	1	mA
R3 (100 mA)	8	mA
R4 (1A)	64	mA

AC Current

True Reading $R_t = | R_{AD} | \bullet$ Scale where Scale and the units of R_t are given in Table A-3.

Ohms

Ohms in the hi-speed mode is the most complex function to convert to a final form. In normal ohms, three voltages are measured to compute the final unknown resistor value. In fast ohms mode, only the primary voltage across the unknown resistor is measured and the 8500A/8502A does the necessary computation to convert this voltage to the resistor value. For hi-speed ohms this computation must be done by the user. The method of determining the conversion factor is as follows:

1. Place a reference resistor, R_c, on the input terminal that is at least 30% of full scale value for the range of interest.
2. Program the command string "Z1F1R?" to obtain the resistor value or force a range (e.g., for the 1 MΩ range program the string "Z1F1R5?"). One reading must be taken in the fast ohms mode in order to correctly enter the high speed ohms mode.
3. The response of the 8500A/8502A will be to return a numeric value for R_c in ASCII format or five byte binary format.
4. Program a "!" to begin the hi-speed mode.
5. The 8500A/8502A will return, in three byte binary (two's complement) form, a number V_c corresponding to the voltage drop across the resistor R_c.
6. Subsequent unknown resistors can be measured by programming a "?" or TTL trigger to the 8502A. The resultant three byte reading will be V_x in the following formula:

$$R = (R_c/| V_c |) \cdot | V_x |$$

where

R = Unknown resistor
R_c = Reference resistor
V_x = Voltage across R
V_c = Voltage across R_c

The following table gives some typical values for each of $R_c \div | V_c |$.

Table A-4

Range	Rc/|Vc|(typ.)
R0 (10Ω)	1.69 Ω/V
R1 (100Ω)	13.5 Ω/V
R2 (1 kΩ)	0.87 kΩ/V
R3 (10 kΩ)	1.73 kΩ/V
R4 (100 kΩ)	111.3 kΩ/V
R5 (1 MΩ)	0.22 MΩ/V
R6 (10 MΩ)	14.3 MΩ/V
R7 (100 MΩ)	114.0 MΩ/V

EXAMPLE
Initial Setup
Range 5 (1 MΩ range) with a 1.53 MΩ resistor on the inputs.

Step 3 yeilds a 1.530000E + 6 for value of R_c.

Step 5 yields the following three byte binary value for V_c. The first byte of data contains the implied binary point at its mid position.

$$\begin{array}{ccc} \text{byte 1} & \text{byte 2} & \text{byte 3} \\ \underbrace{\underset{\wedge}{111\ 0101}} & 00000000 & 00000000 \end{array}$$

sign bit = 1
form 2's complement

$$\begin{array}{ccc} \underbrace{\underset{\wedge}{000\ 1011}}_{0.6875} & \underbrace{00000000}_{0} & \underbrace{00000000}_{0} \end{array}$$

$| V_c | = | -0.6875 \bullet 10 | = 6.875$

$R_c/V_c = 1.53E6/6.875 =$

0.222545 MΩ/V

Step 6 yields following:

$$\begin{array}{ccc} \underbrace{\underset{\wedge}{1111\ 1111}}_{\text{sign bit = 1}} & 11000000 & 00000000 \end{array}$$

form 2's complement

$$\underbrace{0000{}_{\wedge}0000}_{0} \quad \underbrace{0100000}_{.015625} \quad \underbrace{00000000}_{0}$$

$$|V_x| = |-0.015625 \bullet 10| = 0.15625$$

$$R = (R_c/V_c) \bullet V_x$$

$$R = 0.222454 \bullet 0.15265 =$$

$$0.034773\ \mathrm{M}\Omega$$

APPENDIX B

TOGGLE MODE

When programming the 8500A/8502A Duplex Parallel Interface, it is important to note that in a "reset" state or immediately after power is applied, the interface is set to accept and output single byte ASCII characters. In order to communicate with the 8500A/8502A using 16 bit binary or ASCII characters the operator must select the desired format. Since the duplex parallel loads the character into the interface when the data is loaded onto the "Control IN" lines, the programmer is not required to place characters in the most significant byte until such time that the interface is programmed to 16-bit mode. Following are some examples:

1. From 8-bit ASCII to 16-bit ASCII using a 16-bit program.

MSB	LSB
—	/

— don't care

2. From 8-bit ASCII to 16-bit binary using a 16-bit program.

MSB	LSB
—	B
—	1
—	,

or

MSB	LSB
	/
B	1
(space)	,

3. From 8-bit ASCII to 16-bit ASCII using an 8-bit program.

LSB
/

LSB
B
2
,

NOTE: 8 bits "in" means 8 bits "out" and 16 bits "in" means 16 bits "out".

APPENDIX C

% Error Measurement

With the use of scaling and offset the 8500 Series DMM can be used to display a % error measurement.

The typical % error calculation is

$$\%\ \text{Error} = \frac{\text{Value-Reference}}{\text{Reference}} \bullet 100$$

This can be converted to

$$\%\ \text{Error} = \frac{\text{Value}}{.01 \bullet \text{Reference}} - 100$$

Voltage Stimulus

For voltage stimulus the above formula will give a direct reading in % form the 8500A or 8502A.

Measurement Sequence

Step 1. Measure reference voltage

Step 2. Program 1/100 of reference as a scaling factor.

Step 3. Program an offset value of +100.

Step 4. Activate scaling and offset

Step 5. Display (and remote output) indicates directly in %.

Ohms Stimulus

For ohms stimulus there is a difference between the 8500A and the 8502A due to the 8502A's dynamic range. The above formula and measurement sequence (for voltage stimulus) will work for an 8502A only. For the 8500A the factors must be modified per the following table and then the 8500A ohms measurement sequence can be followed.

	WHEN PROGRAMMING		
	Ω Ranges	kΩ Ranges	MΩ Ranges
Error in % Reference Resistor Offset Value	$\times 10^0$ in Ω 100	$\times 10^3$ in kΩ 100E3	$\times 10^6$ in MΩ 100E6

Comments

1. The error in % will be displayed directly on the front panel (the exponent display should be ignored when using the kΩ and MΩ ranges). When using the remote display, the exponent must be handled in software.

2. The reference resistor is first measured, then its value, in the proper units, is multiplied by 0.01 and then programmed as the scaling factor (a standard value may be used in place of the measured value).

Measurement Sequence

Step 1.	Measure reference resistor
Step 2.	Program 1/100 of reference resistance (may be value obtained in step 1 or numeric value) as scaling factor.
Step 3.	Program offset value
Step 4.	Activate offset and scaling
Step 5.	Connect unknown resistor and take measurement.

Current Stimulus

For current stimulus there is a difference between the 8500A and the 8502A due to the 8502A's dynamic range. The above formula and measurement sequence (for voltage stimulus) will work for an 8502A only. For the 8500A the factors must be modified per the following table and then the 8500A current measurement sequence can be followed.

	WHEN PROGRAMMING		
	A Ranges	mA Ranges	μA Ranges
Error in % Reference current Offset Value	$\times 10^0$ in A 100	$\times 10^3$ in mA $100E^{-3}$	$\times 10^6$ in μA $100E^{-6}$

Comments

1. The error in % will be displayed directly on the front panel (the exponent display should be ignored when using the mA and μA ranges). When using the remote display, the exponent must be handled in software.

2. The reference current is first measured, then its value, in the proper units, is multiplied by 0.01 and then programmed as the scaling factor (a standard value may be used in place of the measured value).

Measurement Sequence

Step 1.	Measure reference current
Step 2.	Program 1/100 of reference current (may be value obtained in step 1 or numeric value) as scaling factor.
Step 3.	Program offset value
Step 4.	Activate offset and scaling
Step 5.	Connect unknown current and take measurement.

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Option —02
Ohms Converter

602-1. INTRODUCTION

602-2. Installation of the Ohms Converter provides precision resistance measurement capability ranging from 100 μΩ to 262 MΩ. Both two-terminal and four-terminal measurements may be made.

602-3. SPECIFICATIONS

602-4. Table 602-1 lists the specifications of the Ohms Converter.

602-5. INSTALLATION

602-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing and removing modules. The interconnect diagram in Section 8 contains a table listing permissible and preferred slots.

602-7. OPERATING NOTES

602-8. Operation of the front panel controls with the Ohms Converter Option installed is the same as described in Section 2 of this manual. Eight ranges are available for resistance measurements: 10, 100, 1K, 10K, 100K, 1M, 10M, and 100M. Ranges may be either manually or automatically selected. Four-wire measurements may be made up through the 100K range. In the 1M, 10M, and 100M ranges only two-wire measurements may be made, as lead resistance will not affect accuracy. However, the four-wire connections may still be used if desired. Sense HI to Source HI and Sense LO to Source LO connections must be made either with the shorting links provided (two-wire mode) or at the resistance to be measured (four-wire mode). Figure 602-1 shows possible connections for both the two-wire and four-wire modes.

Table 602-1. Ohms Converter Specifications

ACCURACY (Refer to the specifications table in section 1 for required environmental conditions)						
Range	NORMAL RESOLUTION Accuracy ± (% of Input + No. of Digits)			HIGH RESOLUTION Accuracy ± (% of Input + No. of Digits		
	24 Hours	90 Days	1 Year	24 Hours	90 Days	1 Year
10Ω	0.003 + 20	0.005 + 20	0.01 + 20	–	–	–
100Ω	0.002 + 2	0.003 + 2	0.006 + 2	0.002 + 14	0.003 + 14	0.006 + 14
1 kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
10kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
100 kΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
1 MΩ	0.002 + 1	0.003 + 1	0.006 + 1	0.002 + 8	0.003 + 8	0.006 + 8
10 MΩ	0.01 + 1	0.02 + 1	0.04 + 1	0.01 + 8	0. 02 + 8	0.004 + 8
100 MΩ	0.03 + 1	0.05 + 1	0.1 + 1	0.03 + 8	0.05 + 8	0.1 + 8

Table 602-1. Ohms Converter Specifications (Continued)

OPERATING CHARACTERISTICS

Range	Full Scale	Current Through Unknown	Normal Resolution		High Resolution	
			Resolution	Temperature Coefficient* ± (ppm/rdg + No. of Digits)/°C	Resolution	Temperature Coefficient* ± (ppm/rdg + No. of Digits)/°C
10Ω	31.25Ω	10 mA	100 uΩ	8 + 1.5	–	–
100Ω	250Ω	10 mA	1 mΩ	7 + 0.2	100 uΩ	7 + 2
1 kΩ	2 kΩ	1.25 mA	10 mΩ	7 + 0.2	1 mΩ	7 + 2
10 kΩ	32 kΩ	78 uA	100 mΩ	7 + 0.2	10 mΩ	7 + 2
100 kΩ	256 kΩ	9.8 uA	1Ω	7 + 0.2	100 mΩ	7 + 2
1 MΩ	4.096 MΩ	4.9 uA	10Ω	7 + 0.2	1Ω	7 + 2
10 MΩ	32.768 MΩ	0.61 uA	100Ω	30 + 0.2	10Ω	30 + 2
100 MΩ	262.144 MΩ	76 nA	1 kΩ	50 + 0.2	100Ω	50 + 2

**0°C to 18°C and 28°C to 50°C*

MAXIMUM LEAD RESISTANCE

Mode	Leads	Range	Maximum Lead Resistance
4-wire	Source	10 – 100Ω	10Ω
4-wire	Source	1 kΩ	100Ω
4-wire	Source	10 kΩ – 100 MΩ	1 kΩ
4-wire	Source	All	1 kΩ
2-wire	Source	All	Less than 0.001% of range unless offset

OPEN CIRCUIT VOLTAGE

Range	Voltage	Configuration
10Ω to 100 kΩ	7 volts max	4 Terminal
1 MΩ to 100 MΩ	25 volts max	2 Terminal

OVERLOAD

± 400V dc to 60 Hz, or 560 volts peak ac above 60 Hz maximum continuous on any range with no damage.

SETTLING TIME – (To Rated Accuracy)

80 ms, Fast Filter
800 ms, Slow Filter

DIGITIZING TIME

Mode of Operation	Filter	60 Hz		50 Hz	
		Approx. Rdg. Rate	Digitizing Time	Approx. Rdg. Rate	Digitizing Time
Bench	Fast	4 rdg/s	250 ms	3-1/3 rdg/s	300 ms
	Fast	1-1/2 rdg/s	700 ms	1-1/4 rdg/s	800 ms
	Slow	1-1/4 rdg/s	800 ms	1 rdg	1000 ms
	Slow	5/6 rdg	1200 ms	3/4 rdg	1450 ms
Remote	Fast	4 samples/rdg	145 ms	4 samples/rdg	175 ms
	Slow	4 samples/rdg	700 ms	4 samples/rdg	840 ms
(Subtract for fast Ohms)	Fast	–	110 ms	–	–
	Slow	–	560 ms	–	–

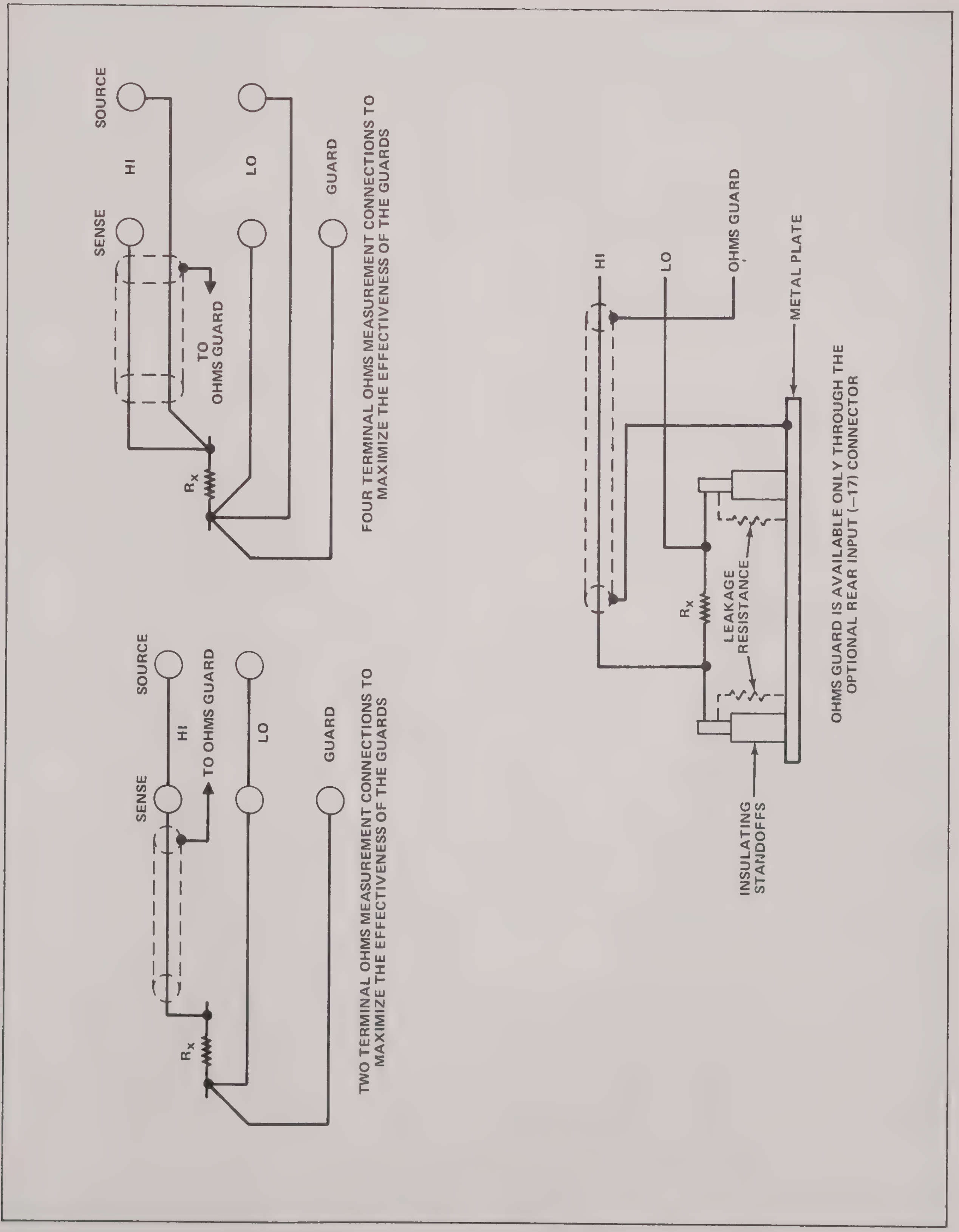

SENSE
SOURCE
HI
LO
GUARD
TO OHMS GUARD
R_x
FOUR TERMINAL OHMS MEASUREMENT CONNECTIONS TO MAXIMIZE THE EFFECTIVENESS OF THE GUARDS
SENSE
SOURCE
HI
TO OHMS GUARD
LO
GUARD
R_x
TWO TERMINAL OHMS MEASUREMENT CONNECTIONS TO MAXIMIZE THE EFFECTIVENESS OF THE GUARDS
HI
LO
OHMS GUARD
METAL PLATE
R_x
LEAKAGE RESISTANCE
INSULATING STANDOFFS
OHMS GUARD IS AVAILABLE ONLY THROUGH THE OPTIONAL REAR INPUT (–17) CONNECTOR

Figure 602-1. Ohms Measurement Connections And Guarding

602-9. For the two-wire ohms mode, the instrument should be zeroed with a good quality short between Sense-Source HI and Sense-Source LO. Select either autoranging or the 10Ω range manually. Depress the STORE switch. Depress the V DC/Ω ZERO switch. All ranges are now automatically zeroed. Ohms zero cannot be recalled. Depressing the RECALL switch while in Ohms results in a display of ERROR 0, then a return to the program. To compensate for lead resistance use the Offset mode. Short the ends of the leads together. Depress the STORE switch, then the OFFSET switch. This enters the lead resistance value into memory. Depress the OFFSET switch again (OFFSET LED illuminated) to enter the Offset mode in which the value of lead resistance will automatically be subtracted from further readings.

602-10. In the four-wire ohms mode, the instrument should be zeroed by placing a good quality short at the ends of the leads. Depress the V DC/Ω ZERO switch to enter the zero value, which will automatically be subtracted from further readings.

602-11. Guarding

602-12. The ohms guard connection is available only through the optional Rear Input Connection (–17). Figure 602-1 shows optimal use of the guard. Basically the ohms guard is used to minimize leakage resistance between the HI and LO leads which would appear as shunt resistance across high R_x values. In some high-resistance measurement set-ups, leakage resistance in or on the surface of insulating materials may provide enough shunt resistance to degrade the accuracy of the measurement. Figure 602-1 illustrates one such case. Connecting the ohms guard to the metal plate on which the standoffs are mounted reduces the effect of leakage resistance through or on the standoffs.

602-13. THEORY OF OPERATION

602-14. The function of the Ohms Converter is to produce a current through an unknown resistance such that the voltage across the unknown is proportional to the value of resistance. This is accomplished by configuring the unknown resistance, R_x, as the feedback element of an operational amplifier. A reference voltage, V_{REF}, is applied through a reference resistor, R_{REF}, to the summing node of the amplifier. By definition of an ideal operational amplifier, the current through R_x is the same current flowing through R_{REF} (the summing node represents a virtual ground). Figure 602-2 is a simplified schematic of the Ohms Converter and contains an illustration of the derivation of the formula for R_x. The current flowing through R_{REF} equals $(V_1 - V_2)/R_{REF}$. Using the expression for current to obtain the value of R_x:

$$R_x = R_{REF} \left(\frac{V_o}{V_1 - V_2}\right).$$

The Ohms Converter multiplexes the voltages which, after being routed through the DC Signal Conditioner and the Filter module, are measured by the A/D Converter.

602-15. The current reference for the Ohms Converter is derived from the –7V reference (RT4) from the A/D Converter. U4 is an inverting amplifier with two possible feedback paths to produce either approximately +2.3V or +18.5V as V_1. U4 drives Q8 with Q8 serving as a larger current source than is available from U4. R41, R45, and R56 are the reference resistors, each having an adjustment.

602-16. R_x is the feedback element for the operational amplifier composed of Q9 and U5. U5 drives Q37 which serves as a higher current source. This arrangement also allows a larger output voltage swing. Note that Q9 and U5 are configured as an inverter, yet the output of U5 is a positive voltage. Q37 draws its emitter current through R48 and R49 from the –30V supply with CR18 and CR13 ensuring that Q37 need not be in a state of saturation. SOURCE voltages out are negative voltages at SOURCE LO with respect to circuit common. In the 100M range, the voltage applied to R41 is divided by 8. However, the unattenuated V_{REF} is measured. The factor of 8 is preserved by assigning R_{REF} the value of 8 x R41 (32.768 MΩ) in the equation. As the Ohms Converter downranges, R41 remains enabled so lower R_{REF} values are actually parallel combinations. V_2 is not measured in the three highest ranges (1M, 10M, 100M) since lead resistance will not be large enough to affect accuracy.

602-17. Extensive overvoltage protection has been provided for the Ohms Converter. Refer to the full schematic. Voltages appearing on the SENSE or SOURCE HI terminals in excess of +28V or –3V (with respect to circuit common) are clamped to ground by Q14, CR7, Q10, and Q39. U5 is configured as a voltage comparator biased by CR19 and R14. The clamping action of Q14 or Q10 causes a voltage on the input Lo line which triggers comparator U5 through Q11 or Q15. In either case the output at U5 pin 7 toggles to its maximum positive level, clocking U3 while placing a high on the ID3 line. This opens relay K1 and removes the input voltages from the module. The high from U5 also inhibits the ACK logic so an Error 4 will be displayed. CR13 and CR14 at the output of Q9, U5 are high voltage blocking diodes. E1 is a spark gap preventing voltages in excess of 400V between the guard shield and circuit common.

602-18. The Ohms Converter is addressed by IC1, 2, 3 high, and must be addressed for each sample voltage. Samples are multiplexed out at the rate of one every four msec. This requires the fastest response time in the DC Signal Conditioner of any measurement mode.

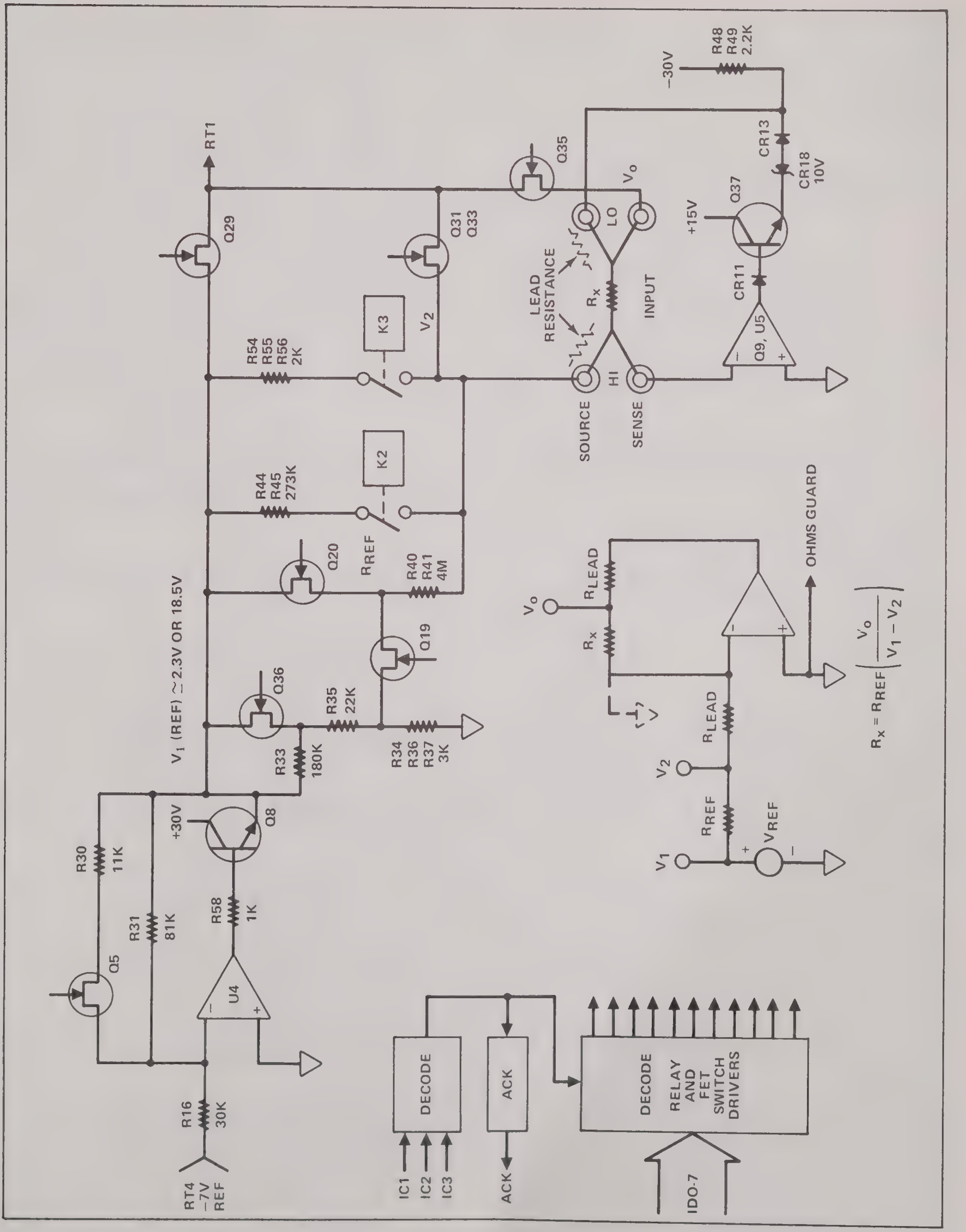

RT1
Q29
Q35
Q31
Q33
Vo
LO
LEAD RESISTANCE
Rx
INPUT
HI
SOURCE
SENSE
V2
K3
K2
R54
R55
R56
2K
R44
R45
273K
Q20
RREF
R40
R41
4M
Q19
Q36
R35
22K
R34
R36
R37
3K
R33
180K
V1 (REF) ≃ 2.3V OR 18.5V
Q8
+30V
R30
11K
R31
81K
R58
1K
Q5
U4
R16
30K
RT4
−7V
REF
−30V
R48
R49
2.2K
CR13
CR18
10V
Q37
+15V
CR11
Q9, U5
Vo
RLEAD
Rx
RLEAD
V2
RREF
V1
VREF
OHMS GUARD
Rx = RREF (Vo / (V1 − V2))
DECODE
ACK
DECODE
RELAY AND FET SWITCH DRIVERS
IC1
IC2
IC3
ACK
IDO-7

Figure 602-2. Ohms Converter

602-19. MAINTENANCE

602-20. Performance Test

602-21. Test the Ohms function using the following procedure:

1. Connect test leads to the instrument in the four-wire configuration.
2. Select the Ohms function and Autoranging.
3. Short the HI and LO Ω SOURCE leads, short the HI and LO SENSE leads; then connect the two pairs of shorted leads together.
4. Zero the instrument by depressing the STORE switch, then the V DC/Ω ZERO switch.
5. Remove the shorts and sequentially connect the standard resistors in Table 602-2. The 8500A readings should fall within the limits specified.

Table 602-2. Performance Test

Standard Resistor	8500A Reading	
	Low (exponent)	High (exponent)
10	9.9975	10.0025
100	99.995	100.005
1K	.99996 (+3)	1.00004 (+3)
10K	9.9996 (+3)	10.0004 (+3)
100K	99.996 (+3)	100.004 (+3)
1M	.99996 (+6)	1.00004 (+6)
10M	9.9979 (+6)	10.0021 (+6)
100M	99.949 (+6)	100.051 (+6)

602-22. Calibration

602-23. Use the following procedure to calibrate the Ohms Converter:

1. Remove power and remove the Calibration Memory if installed.
2. Reapply power and allow a two hour warm-up.
3. Ensure that the dc Volts accuracy is within tolerance.
4. Short the HI and LO AMPS/Ω SOURCE terminals, short the HI, LO and GUARD VOLTS/Ω SENSE terminals, then short the two HI terminals. Use the terminal shorting links provided with the instrument and/or equivalents.
5. Use manual range selection to prevent range changes while testing at the range extremities.
6. Select the 10Ω range on the DMM.
7. Adjust R24 for a reading between -0.0003 and +0.0003.
8. Step through the other seven ranges, checking that the reading is 0 ± 1 digit on all seven ranges.
9. Remove the shorting links and make four-wire ohms measurement connections to the INPUT terminals. Select the 1MΩ range and connect the input leads to a 4 MΩ standard resistor.

NOTE
Refer to Table 4-1 of the Instruction Manual for specifications on the Standard Resistors.

10. Adjust R40 for a reading between 3.99998 (+6) and 4.00002 (+6).
11. Select the 100 MΩ range and connect the input leads to a 100 MΩ standard resistor.
12. Adjust R37 for a reading between 99.995 (+6) and 100.005 (+6).
13. Select the 100 kΩ range and connect the input leads to a 250 kΩ standard resistor.
14. Adjust R44 for a reading between 249.998 (+3) and 250.002 (+3).
15. Select the 1 kΩ range and connect the input leads to a 1.9 kΩ standard resistor.
16. Adjust R54 for a reading between 1.89998 (+3) and 1.90002 (+3).
17. Select the 10Ω range and short the four-terminal leads for a zero input.
18. Perform the Ohms Zero procedure found in the operating instructions, ensuring the result is 0.0000 ± 1 digit.
19. Perform the tests in Table 602-3. There are no adjustments for the readings, if any reading exceeds the listed tolerance the module is not acceptable.

Table 602-3. Calibration Tests

Resistance Standard	Readings		
	Minimum	Nominal	Maximum
10	9.9989	10.0000	10.0011
100	99.997	100.000	100.003
1k	0.99997 (+3)	1.00000 (+3)	1.00003 (+3)
10k	9.9997 (+3)	10.0000 (+3)	10.0003 (+3)
100k	99.997 (+3)	100.000 (+3)	100.003 (+3)
1M	0.99997 (+6)	1.00000 (+6)	1.00003 (+6)
10M	9.9989 (+6)	10.0000 (+6)	10.0011 (+6)
100M	99.969 (+6)	100.000 (+6)	100.031 (+6)

602-24. TROUBLESHOOTING

602-25. Troubleshooting procedures for the Ohms Converter follow the format used for the mainframe instrument. Table 602-4, Failure Isolation, assures that the problem is in the Ohms Converter. Table 602-5 lists symptoms and possible failures in the order of probability. Figure 602-3 shows timing relationships, while Tables 602-6 through 602-8 give additional troubleshooting information.

602-26. Always remove power before removing or installing modules. RT1 is available only in the front four option slots and not in the Isolator or Interconnect slot.

602-27. PARTS LIST

602-28. Table 602-9 is a parts breakdown for the Ohms Converter. Refer to Section 5 of this manual for ordering and use code information.

Table 602-4. Failure Isolation

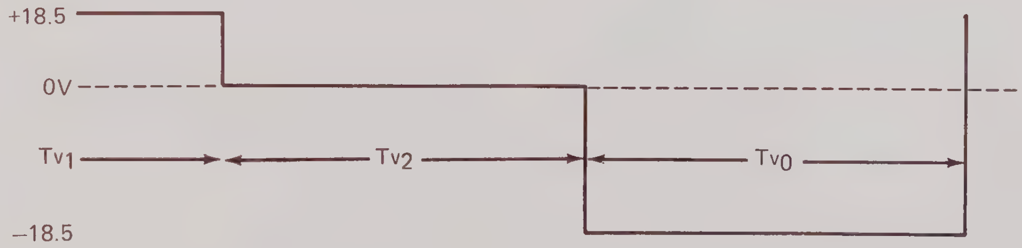
STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Perform DC Volts test (Section 4). Is DC Volts within tolerance?	2	Section 4
2	Perform Ohms test. Is Ohms within tolerance?	Section 4	3
3	Remove all optional modules except Isolator and Ohms converter.		
4	Is Ohms now within tolerance?	5	6
5	An optional module is affecting Ohms. Replace one at a time until Ohms goes bad. Last one in is faulty – go to appropriate portion of Section 6.		
6	Is Isolator installed?	7	9
7	Remove Isolator. Insert Jumper/Monitor pcb. Is Ohms within tolerance:	8	9
8	Bad Isolator. Go to Subsection 608.		
9	Check power supply voltages as follows. Test DMM LO on AR (analog return). VA1 = +14.25 to 15.75V VA2 = –14.25 to –15.75V VA3 = +29 to 32V VA4 = –29 to –32V $\left.\begin{array}{l}\text{Vcc} = -15\text{V}\\ \text{Vss} = -20\text{V}\end{array}\right\}$ Difference = 4.9 to 5.2 RT4 = –6.993 to –7.007		
10	Are the supply voltages within tolerance?	11	Section 4
11	The problem is probably in the Ohms board. However, the DC Signal Conditioner may contribute errors if the slew rates of the amplifiers are not fast enough. Go to Table 602-5.		

Table 602-5. Symptom Analysis

SYMPTOM	POSSIBLE FAILURE
No Ohms Readings (V_0)	U5, Q9, Q35, Digital Logic
(V_1)	U4, Q8, Q29 Digital Logic & Drivers
Ohms Zero Drift	U5, Q9
10K – 100K Ranges Bad	Q32, Q33, Digital
10 – 100 – 1K Ranges Bad	Q30, Q31, Digital
10M Full Scale Low	Q20, Q22
No ACK	U5, Q14, Q11, Q38
All Ranges Out of Tolerance	Q37, U5
100M Noisy, 30M High	Q10, K3 Shorted
1K, 100K, 10M, 100M Ranges Bad	Q5, Q4
100M Range Bad	Q20, Q22, Q19 Leaky
Display Error 4 with no voltage at input	Q14
Noisy at 30M or Full Scale	CR15, CR17, CR4, CR8
Full Scale 1M, 10M, 100M Ranges Out of Tolerance	CR18
DC SIGNAL CONDITIONER	
Slew Rates Bad	Q37, Q38, Q19, U3, U5, U6

Note: If Q9, Q19, U5, R19, R20, R21, R23, R25, or R26 are replaced it is necessary to return the module to the factory (Attn: Parts) for temperature compensation.

Voltages shown are at RT6, (DC Signal Conditioner Output).



Vo is proportional to Rx, Vo for full scale Rx is shown.

Sample Rate	Filter	Tv_1	Tv_2 *	Tv_0
Fast	No	30ms	30ms	200 ms
Fast	Yes	30ms	30ms	650ms
Slow	No	30ms	30ms	600ms
Slow	Yes	30ms	30ms	1060ms

These are approximate times.

*Except Tv_2 for ranges 1M, 10M, 100M is zero. No V_2 is measured for these ranges.

The first reading after a range change or overrange is modified with longer V_1 and V_2 periods.

Figure 602-3. Timing

Table 602-6. Voltage Measurements

Range	Full Scale	V* TP2	R ref	I ref* (Source HI)	V_0* (Range Value)	V_1* (TP2)	V_2 (Offset)
10	31.25	+18.5V	2K	9.3ma	.093V	+18.5	< 100mv
100	250	+18.5V	2K	9.3ma	.93V	+18.5	< 100mv
1000	2000	+2.3V	2K	1.2ma	1.2V	+2.3	< 100mv
10K	32K	+18.5V	256K	72μa	.72V	+18.5	< 100mv
100K	256K	+2.3V	256K	9μa	.9V	+2.3	< 100mv
1M	4.091M	+18.5V	4.091M	4.5μa	4.5V	+18.5	NA
10M	32.728M	+2.3V	4.091M	.56μa	5.6V	+2.3	NA
100M	261.824M	+2.3V/8	4.091M	70na	7V	+2.3	NA

* Approximate values (± 5%)

TP1 is always −7.0V
TP3 Ref common (use for low side of measurements)
TP4 amplifier offset (<10μv properly adjusted)
V_0 is proportional to RX
V_2 will vary some with range change

SCANNER: Voltages will appear on RT1 in order. $V_0 - V_1 - V_2$

Table 602-7. Range Switch Closures

0 = Switch Open

1 = Switch Closed

Chart applies for time the particular voltage is SCANNED. All other times "0" applies.

	K1	K2	K3	Q5	Q19	Q20	V_0 Q29	V_{2a} Q31	V_{2b} Q33	V_1 Q35
10Ω	1	0	1	0	0	1	1	1	0	1
100Ω	1	0	1	0	0	1	1	1	0	1
1KΩ	1	0	1	1	0	1	1	1	0	1
10KΩ	1	1	0	0	0	1	1	0	1	1
100KΩ	1	1	0	1	0	1	1	0	1	1
1MΩ	1	0	0	0	0	1	1	0	0	1
10MΩ	1	0	0	1	0	1	1	0	0	1
100MΩ	1	0	0	1	1	0	1	0	0	1
OHMS	0	0	0	1	0	1	0	0	0	0

Table 602-8. Address and Data Coding

ADDRESS IC1, 2, 3 HIGH									
Range	V	ID0	ID1	ID2	ID3	ID4	ID5	ID6	ID7
10	V_0	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
100	V_0	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
1K	V_0	0	1	1	0	1	1	1	0
	V_1	1	0	1	0	1	1	1	0
	V_2	1	1	0	0	1	1	1	0
10K	V_0	0	1	1	0	0	0	1	1
	V_1	1	0	1	0	0	0	1	1
	V_2	1	1	0	0	0	0	1	1
100K	V_0	0	1	1	0	1	0	1	1
	V_1	1	0	1	0	1	0	1	1
	V_2	1	1	0	0	1	0	1	1
1M	V_0	0	1	1	0	0	1	1	1
	V_1	1	0	1	0	0	1	1	1
10M	V_0	0	1	1	0	1	1	1	1
	V_1	1	0	1	0	1	1	1	1
100M	V_0	0	1	1	0	1	1	0	1
	V_1	1	0	1	0	1	1	0	1
OHMS		1	1	1	1	1	1	1	1

Table 602-9. Ohms Converter PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-02	⊗OHMS CONVERTER PCB ASSEMBLY FIGURE 602-4 (MIS-4110T)	ORDER	BY	OPTION -02			
C1	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	4		
C2	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C3	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C4	CAP, TA, 6.8 UF +/-20%, 35V	363713	56289	196D685X0035KA1	REF		
C5	CAP, CER, 33 PF +/-2%, 100V	354852	80031	2222-638-10339	1		
C6	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	2		
C7	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	REF		
C8	CAP, POLYSTRYRN, 100 PF +/-10%, 500V	446609	89536	446609	1		
C9	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	7		
C10	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C11	CAP, TA, 22 UF +/-20%, 15V	423012	56289	196D226X0015KA1	1		
C12	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C13	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C14	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C15	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C16	CAP, TA, 5.6 UF +/-20%, 25V	368869	56289	196D565X0025KA1	1		
C17	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	3		
C18	CAP, TA, 0.47 UF +/-20%, 35V	161349	56289	196D474X0035HA1	1		
C19	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C20	CAP, CER, 0.0022 UF +/-10%, 500V	268425	32897	851000Z5R222K	1		
C21	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C22	CAP, TA, 0.33 UF +/-20%, 35V	408690	56289	196D334X0035HA1	1		
C23	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
CR1	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	6	2	
CR2	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, SI, RECT	428144	01295	1N4006	7	2	
CR7	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR8	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR9	DIODE, ZENER, UNCOMP	113324	07910	1N961A	2	1	
CR10	DIODE, SI, MULTIPELLET	375485	09214	MPD300	2	1	
CR11	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR12	DIODE, SI, MULTIPELLET	375485	09214	MPD300	REF		
CR13	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR14	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR15	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR16	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR17	DIODE, SI, RECT	428144	01295	1N4006	REF		
CR18	DIODE, ZENER, UNCOMP	113324	07910	1N961A	REF		
CR19	DIODE, 2-PELLET	375477	09214	MPD200	1	1	
CR20	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
E1	SURGE PROTECTOR, VOL	442723	25088	B1-C145	1		
H1	SCREW, PHP, 4-40 X 5/8	413062	89536	413062	1		
K1	RELAY, ARMATURE	515429	89536	515429	1		
K2	RELAY, DRY REED	357582	71707	UF40070	2		
K3	RELAY, DRY REED	357582	71707	UF40070	REF		
L1	CHOKE, RF	111542	99800	1537-76	1		

Table 602-9. Ohms Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
MP1	CASE ASSY (INCLUDES MP2-MP9)	458927	89536	458927	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411942	89536	411942	REF		
MP6	DECAL, OHMS CONVERTER	413435	89536	413435	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP11	SPACER, XSTR	152207	07047	10123-DAP	5		
MP12	SOCKET, COMPONENT LEAD (NOT SHOWN) (W/R20,R21,R23,R26)	343285	00779	2-331272-6	8		
MP13	LUG, SOLDER	103531	77963	501	1		
MP14	SPRING, COIL (NOT SHOWN)	424465	83553	C0120-014-0380	1		
Q1	XSTR, SI, NPN	226290	04713	MPS3640	1	1	
Q2	XSTR, SI, NPN	218396	04713	2N3904	14	3	
Q3	XSTR, SI, PNP	195974	04713	2N3906	7	2	
Q4	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q5	XSTR, FET, N-CHANNEL	261578	89536	261578	4	1	
Q6	XSTR, SI, PNP	168716	07263	S19254	3	1	
Q7	XSTR, SI, PNP	168716	07263	S19254	REF		
Q8	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q9	XSTR, FET, DUAL, N-CHANNEL	476309	89536	476309	1	1	
Q10	XSTR, SI, NPN	203489	09214	11C2322	5	1	
Q11	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q12	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q13	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q14	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q15	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q16	XSTR, SI, NPN	203489	09214	11C2322	REF		
Q17	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q18	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q19	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q20	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q21	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q22	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q23	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q24	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q25	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q26	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q27	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q28	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q29	XSTR, FET, N-CHANNEL	393314	89536	393314	4	1	
Q30	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q31	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q32	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q33	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q34	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q35	XSTR, FET, N-CHANNEL	393314	89536	393314	REF		
Q36	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		

Table 602-9. Ohms Converter PCB Assembly (cont)

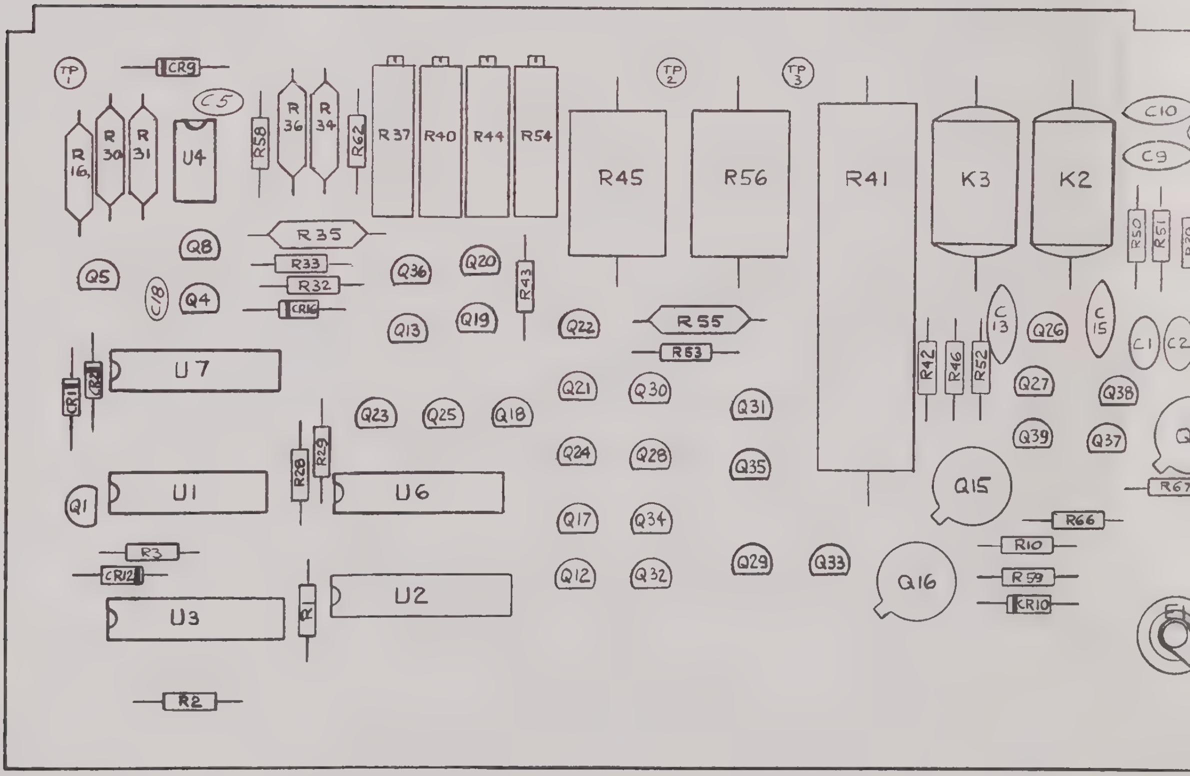
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q38	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q39	XSTR, SI, PNP	168716	07263	S19254	REF		
Q40	XSTR, FET JUNCTION, N-CHANNEL	288324	89536	288324	1	1	
R1	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	7		
R2	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	6		
R3	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R4	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R5	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R6	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R7	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R8	RES, COMP, 220K +/-5%, 1/2W	109025	01121	EB2245	1		
R9	RES, COMP, 1.8K +/-5%, 1W	180331	01121	GB1825	2		
R10	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R11	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R12	RES, COMP, 100K +/-5%, 1W	109397	01121	GB1041	1		
R14	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R16	RES, MTL. FILM, 30.1K +/-1%, 1/8W	293431	91637	MFF1-83012F	1		
R17	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	6		
R18	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R19	RES, WW, 40K +/-0.1%	271403	89536	271403	2		
R20	RES, SELECTED				1		
R21	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	2		
R23	RES, SELECTED				REF		
R24	RES, VAR, CERMET, 100 +/-20%, 1/2W	267823	11236	190PC101B	1		
R25	RES, WW, 40K +/-0.1%	271403	89536	271403	REF		
R26	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	REF		
R27	RES, MTL. FILM, 20K +/-1%, 1/8W	291872	91637	MFF1-82002F	1		
R28	RES, DEP. CAR, 39K +/-5%, 1/4W	442400	80031	CR251-4-5P39K	2		
R29	RES, DEP. CAR, 39K +/-5%, 1/4W	442400	80031	CR251-4-5P39K	REF		
R30	RES, MTL. FILM, 11.3K +/-1%, 1/8W	335414	91637	MFF1-81132F	1		
R31	RES, MTL. FILM, 80.6K +/-1%, 1/8W	312710	91637	MFF1-88062F	1		
R32	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R33	RES, DEP. CAR, 180K +/-5%, 1/4W	348946	80031	CR251-4-5P180K	1		
R34	RES, MTL. FILM, 3.16K +/-0.1%, 1/8W	340588	91637	MFF1-83161B	1		
R35	RES, MTL. FILM, 21.5K +/-0.1%, 1/8W	344440	91637	MFF1-82152B	1		
R36	RES, MTL. FILM, 100K +/-1%, 1/8W	248807	91637	MFF1-81003F	1		
R37	RES, VAR, CERMET, 50K +/-10%, 1/2W	330688	11236	190PC503B	1		
R39	RES, DEP. CAR, 1.6K +/-5%, 1/4W	348805	80031	CR251-4-5P1K6	1		
R40	RES, VAR, CERMET, 10K +/-10%, 1/2W	267880	11236	190PC103B	1		
R41	RES, WW, 4.091M +/-0.1%, 2W	412205	89536	412205	1		
R42	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R43	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R44	RES, VAR, CERMET, 500 +/-20%, 1/2W	267849	11236	190PC501B	1		
R45	RES, WW, 272.84K +/-0.08%, 1/2W	412197	89536	412197	1		
R46	RES, DEP. CAR, 3.3K +/-5%, 1/4W	348813	80031	CR251-4-5P3K3	1		
R47	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	4		
R48	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	2		
R49	RES, COMP, 1.8K +/-5%, 1W	180331	01121	GB1825	REF		
R50	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	2		
R51	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	REF		

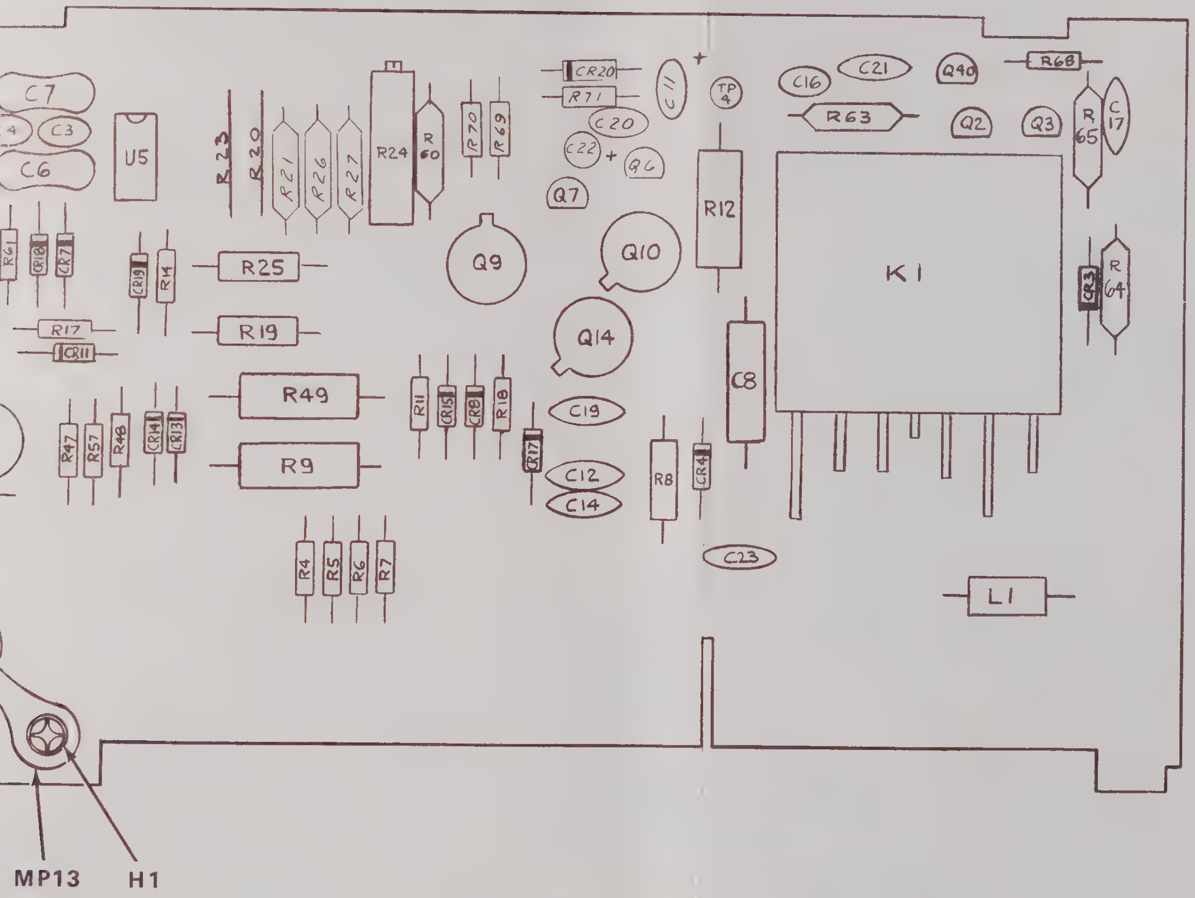
Table 602-9. Ohms Converter PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R52	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R53	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R54	RES, VAR, CERMET, 200K +/-20%, 1/2W	381509	11236	190PC204B	1		
R55	RES, MTL. FILM, 332K +/-1%, 1/8W	289504	91637	MFF1-83323F	1		
R56	RES, WW, 2.01K +/-0.1%, 1/2W	412189	89536	412189	1		
R57	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	REF		
R58	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	2		
R59	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R60	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	MFF1-81004F	1		
R61	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R62	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R63	RES, MTL. FILM, 15.8K +/-1%, 1/8W	293688	91637	MFF1-81582F	1		
R64	RES, MTL. FILM, 73.2K +/-1%, 1/8W	237222	91637	MFF1-87322D	1		
R65	RES, MTL. FILM, 30.1K +/-1%, 1/8W	168286	91637	MFF1-83012F	1		
R66	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R67	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R68	RES, DEP. CAR, 560K +/-5%, 1/4W	342642	80031	CR251-4-5P560K	1		
R69	RES, DEP. CAR, 300 +/-5%, 1/4W	441519	80031	CR251-4-5P300E	1		
R70	RES, DEP. CAR, 200K +/-5%, 1/4W	441485	80031	CR251-4-5P200K	1		
R71	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	REF		
U1	⊗IC, C-MOS, NAND GATES	375147	02735	CD4023AE	1	1	
U2	⊗IC, C-MOS, QUAD, CLOCKED "D" LATCH	355149	02735	CD4042AE	2	1	
U3	⊗IC, C-MOS, QUAD, CLOCKED "D" LATCH	355149	02735	CD4042AE	REF		
U4	IC, LIN, OPNL AMPL	363515	34333	SG301A	1	1	
U5	IC, LIN, OPNL AMPL	418566	12040	LM358N	1	1	
U6	IC, RES NETWORK	380618	89536	380618	2	1	
U7	IC, RES NETWORK	380618	89536	380618	REF		

1 SEE TABLE 5-17 AT THE END

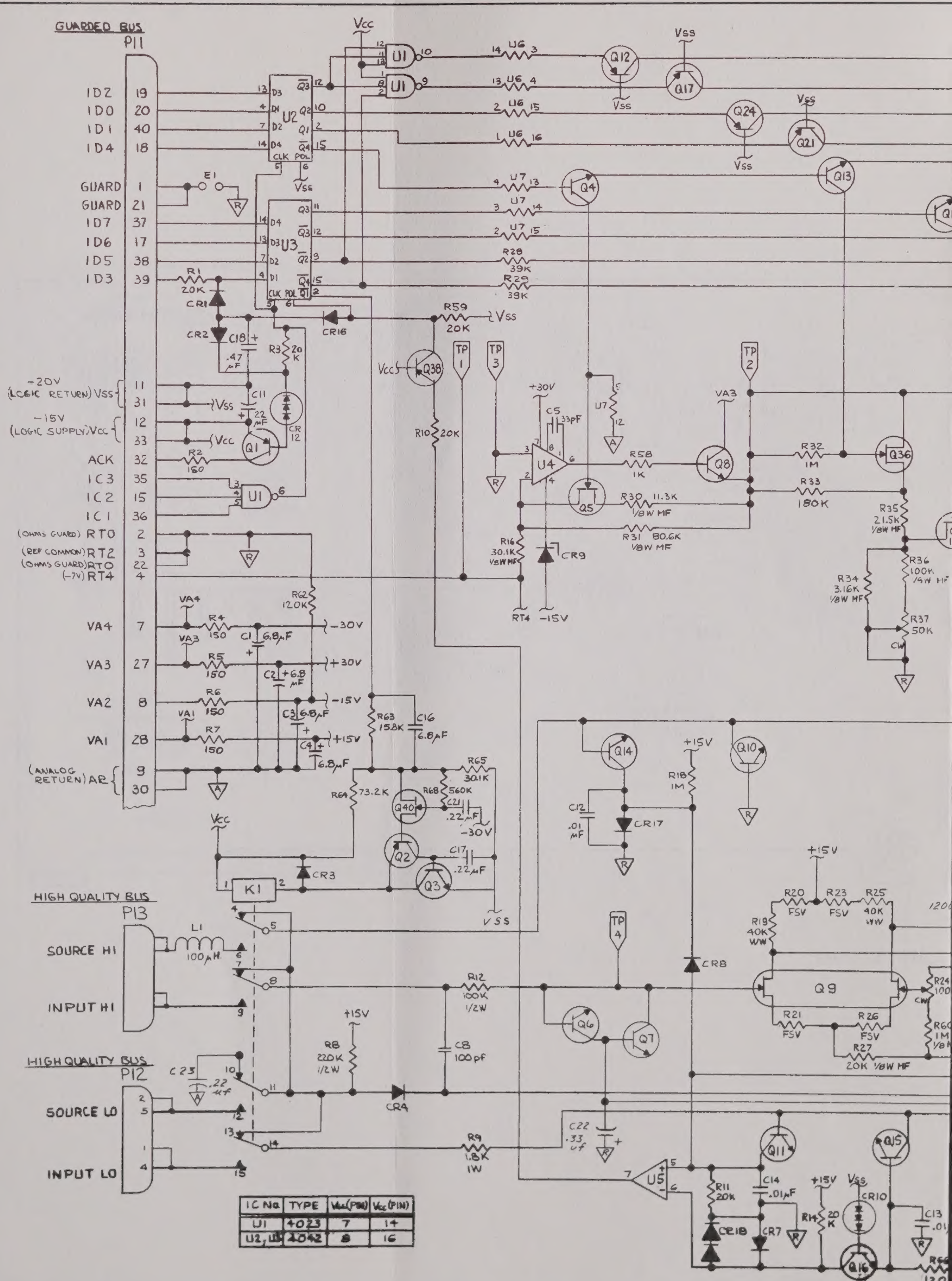
OF SECTION 5.


TP 1
CR9
C5
R 16
R 30
R 31
U4
R58
R 36
R 34
R62
R37
R40
R44
R54
TP 2
TP 3
R45
R56
R41
K3
K2
C10
C9
R50
R51
R35
Q8
R33
R32
CR16
Q5
C18
Q4
Q36
Q20
R43
Q13
Q19
Q22
R55
R53
C 13
Q26
C 15
C1
C2
U7
CR11
CR14
R42
R46
R52
Q27
Q38
Q21
Q30
Q31
Q23
Q25
Q18
Q24
Q28
Q35
Q39
Q37
R28
R29
Q15
U1
U6
Q1
R67
R66
Q17
Q34
R10
R3
CR12
Q12
Q32
Q29
Q33
Q16
R59
U2
CR10
U3
R1
R2

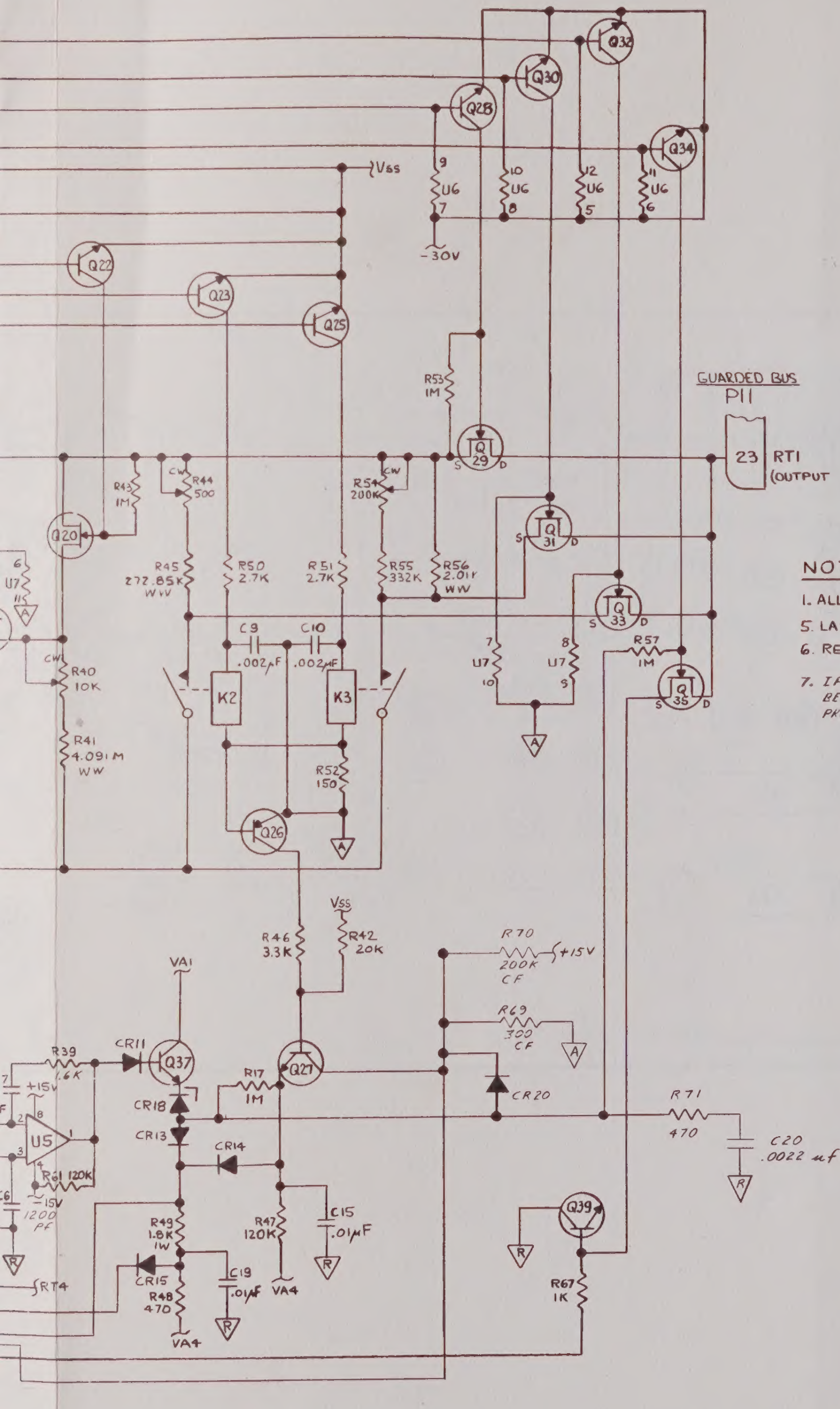

C7
C3
C6
U5
R23
R20
R21
R26
R27
R24
R60
R70
R69
CR20
R71
C20
C22
Q6
Q7
C11
TP4
C16
C21
Q40
R68
R63
Q2
Q3
R65
C17
R61
CR18
CR7
CR19
R14
R25
R19
R17
CR11
R49
R9
R47
R57
R48
CR14
CR13
Q9
Q10
Q14
R12
K1
CR3
R64
C8
R11
CR15
CR8
R18
C19
CR17
C12
C14
R8
CR4
C23
L1
R4
R5
R6
R7
MP13
H1

MIS-1710

Figure 602-4. Ohms Converter PCB Assembly


GUARDED BUS
P11
ID2 19
ID0 20
ID1 40
ID4 18
GUARD 1
GUARD 21
ID7 37
ID6 17
ID5 38
ID3 39
-20V (LOGIC RETURN) VSS 11 31
-15V (LOGIC SUPPLY) VCC 12 33
ACK 32
IC3 35
IC2 15
IC1 36
(OHMS GUARD) RT0 2
(REF COMMON) RT2 3
(OHMS GUARD) RT0 22
(-7V) RT4 4
VA4 7
VA3 27
VA2 8
VA1 28
(ANALOG RETURN) AR 9 30
E1
R1 20K
CR1
CR2
C18 .47 µF
R3 20K
C11 22 µF
CR12
Q1
R2 150
U1
U2
U3
Vcc
Vss
U6
U7
Q12
Q17
Q24
Q21
Q4
Q13
R28 39K
R29 39K
R59 20K
CR16
Q38
TP 1
TP 3
TP 2
TP 4
R10 20K
+30V
C5 33pF
U4
R58 1K
Q8
Q5
VA3
R32 1M
R33 180K
Q36
R30 11.3K 1/8W MF
R31 80.6K 1/8W MF
R16 30.1K 1/8W MF
CR9
RT4 -15V
R35 21.5K 1/8W MF
R36 100K 1/4W MF
R34 3.16K 1/8W MF
R37 50K
CW
R62 120K
R4 150
R5 150
R6 150
R7 150
C1 6.8µF
C2 6.8 µF
C3 6.8µF
C4 6.8µF
-30V
+30V
-15V
+15V
R63 15.8K
C16 6.8µF
R65 30.1K
R64 73.2K
R68 560K
Q40
C21 .22µF
Q2
Q3
C17 .22µF
CR3
K1
VSS
Q14
Q10
R18 1M
C12 .01 µF
CR17
HIGH QUALITY BUS
P13
SOURCE HI
INPUT HI
L1 100µH
R12 100K 1/2W
C8 100pf
Q6
Q7
R8 220K 1/2W
CR4
CR8
Q9
R19 40K WW
R20 FSV
R23 FSV
R25 40K WW
R21 FSV
R26 FSV
R27 20K 1/8W MF
R24 100
R60 1M 1/8
HIGH QUALITY BUS
P12
SOURCE LO
INPUT LO
C23 .22 uf
C22 .33 uf
R9 1.8K 1W
U5
Q11
Q15
R11 20k
C14 .01µF
CR18
CR7
R14 20K
CR10
Q16
C13 .01
120

IC No.	TYPE	Vss(PIN)	Vcc(PIN)
U1	4023	7	14
U2, U3	4042	8	16


Q32
Q30
Q28
Q34
Vss
9 U6 7
10 U6 8
12 U6 5
11 U6 6
-30V
Q22
Q23
Q25
R53 1M
GUARDED BUS
P11
23 RT1 (OUTPUT
Q 29 S D
CW R44 500
R43 1M
R54 200K CW
Q20
Q 31 S D
R45 272.85K WW
R50 2.7K
R51 2.7K
R55 332K
R56 2.01K WW
6 U7 11
Q 33 S D
R57 1M
Q 35 S D
C9 .002μF
C10 .002μF
K2
K3
7 U7 10
8 U7 9
CW R40 10K
R41 4.091M WW
R52 150
Q26
A
Vss
R46 3.3K
R42 20K
VA1
R70 200K CF +15V
R69 300 CF
R39 1.6K
CR11
Q37
Q27
R17 1M
CR20
+15V
CR18
CR13
U5
CR14
R71 470
C20 .0022 uf
R61 120K
-15V
1200 PF
R49 1.8K 1W
R47 120K
C15 .01μF
Q39
CR15
C19 .01μF
VA4
RT4
R48 470
VA4
R67 1K
R
VA4

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTORS 1/4W, CC, AND ALL RESISTANCE IN OHMS.

5. LAST REF. DES No'S USED: U7, Q40, CR20, K3, E1, R70, C22.

6. REF. DES. No'S NOT USED: CR5, CR6, R13, R15, R22, R38.

7. IF Q19, U5, R19, R20, R21, R23, R25 OR R26 ARE REPLACED, IT BECOMES NECESSARY TO TC THE MODULE PER MIS-4110-151 TEST PROCEDURE.

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Figure 602-4. Ohms Converter PCB Assembly (cont)

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